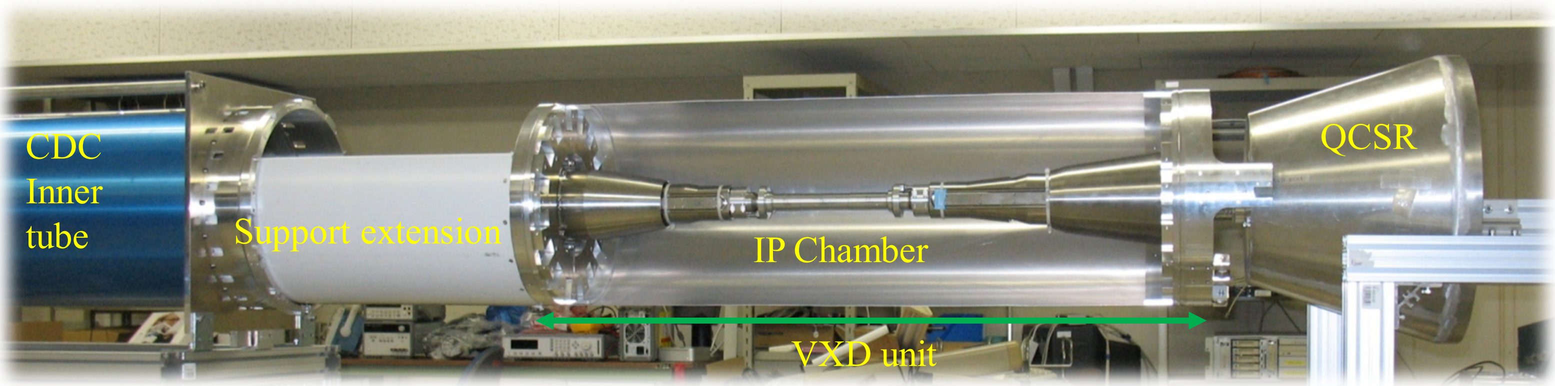
Construction of the Interaction Region



The 18th KEKB Accelerator Review Committee
KEK, 4-6 March 2013

K. Kanazawa
for
KEKB Vacuum Group
IR Technical Meeting Member
IR Installation Meeting Member
SVD/IR Mechanics Meeting Member

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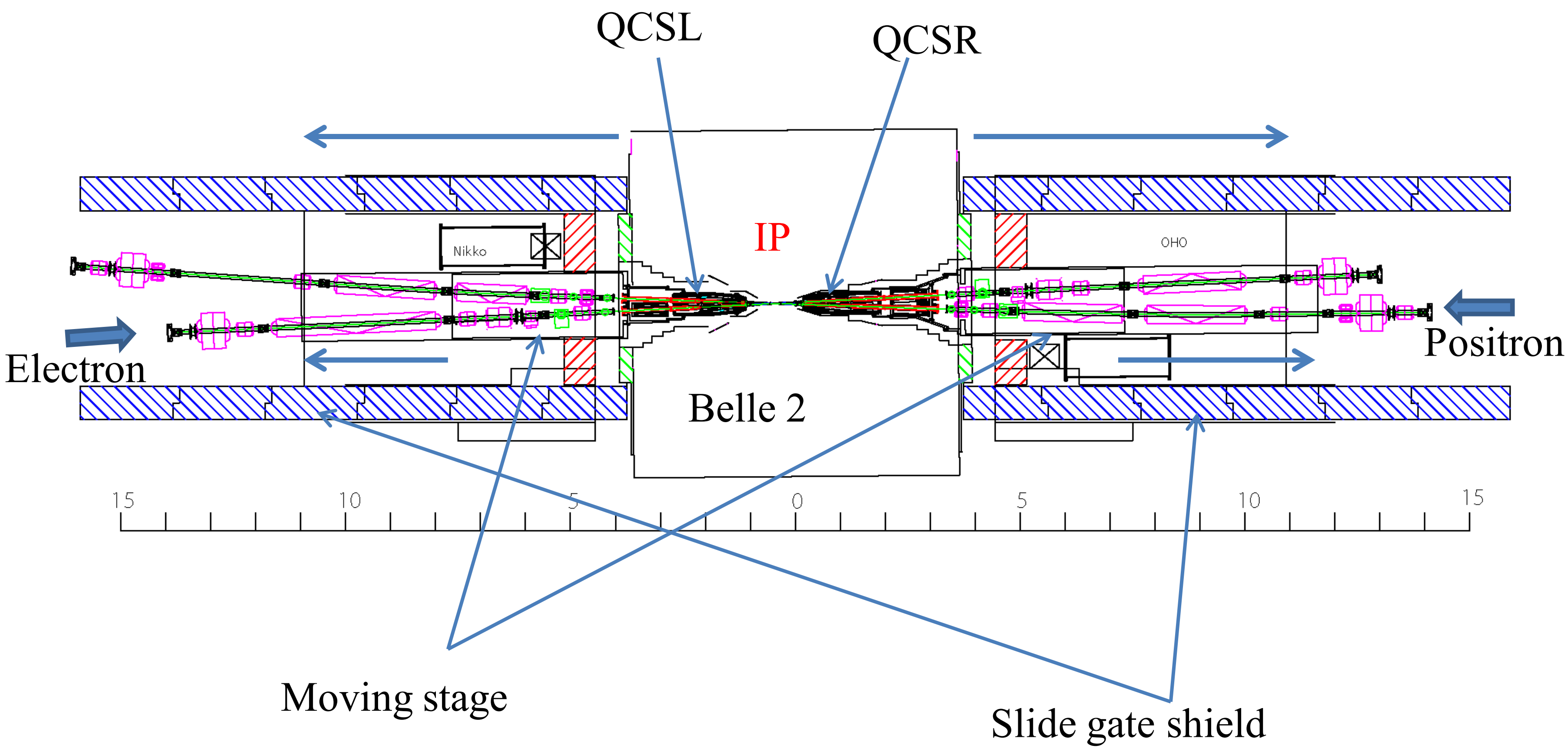
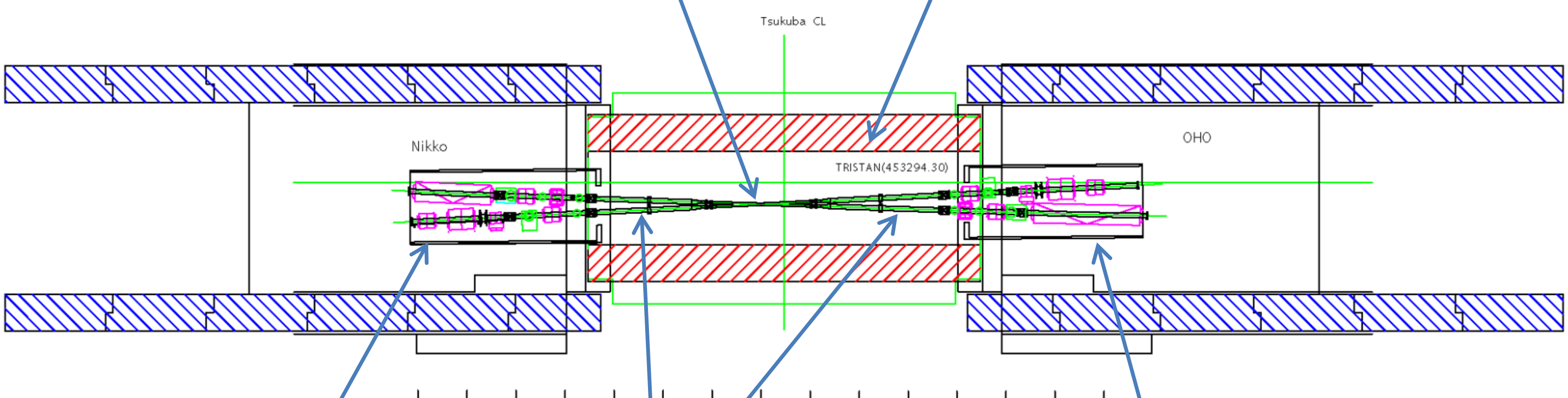


Sketch of the Interaction Region

Phase 1

Al IP chamber
(ID 4 cm, ~2 m long)

Temporal shield
(on the temporal stage)



Moving stage
without
QCSL support

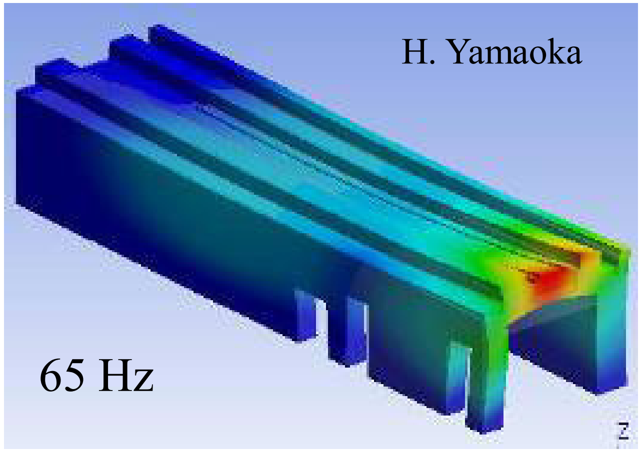
Copper ducts with BPM

Fixed temporal stage

Mile-stone and Task Schedule

	date	Belle rotation	QCS	Special magnets	Bridge reinforcement	QCS support and Moving stage	IP chamber	Ta beam pipe for QCS	Vacuum system	Installation scenario	Back ground estimation and Radiation shield	LABM	Luminosity monitor
		Belle	MG(Cryo)	MG	MG	MG	Belle/VAC	VAC/MG(Cryo)	VAC	Belle/VAC	Belle/RSC/Acc	BM	Belle/Acc
Now	- Mar 2013	Complete first stage	QCSL under fabrication		Decision							Fix position	
	Apr 2013 - Feb 2014		QCSR fabrication start QCSL complete		(Must end before Oct 2013)	Bridge work L side complete	Ver. 1 final fabrication			Select scenario			
QCSL test at IR	Mar 2014 - Aug 2014		In situ test of QCSL			Mechanical test (L side)							
	Sep 2014 - Dec 2014			Installation					complete		Phase 1 shield complete	Set up complete	
Phase 1	Jan 2015 - May 2015		QCSR complete?					complete		Preparation complete		System test	
	Jun 2015 - Dec 2015	Final adjust	QCS installation							1 st test	Phase 2 shield complete		
Phase 2	Jan 2016 - Apr 2016						Beast Feedback to var. 2 ?			Improvement			
	May 2016 - Sep 2016										additional		
Phase 3	Oct 2016												

Bridge Reinforcement

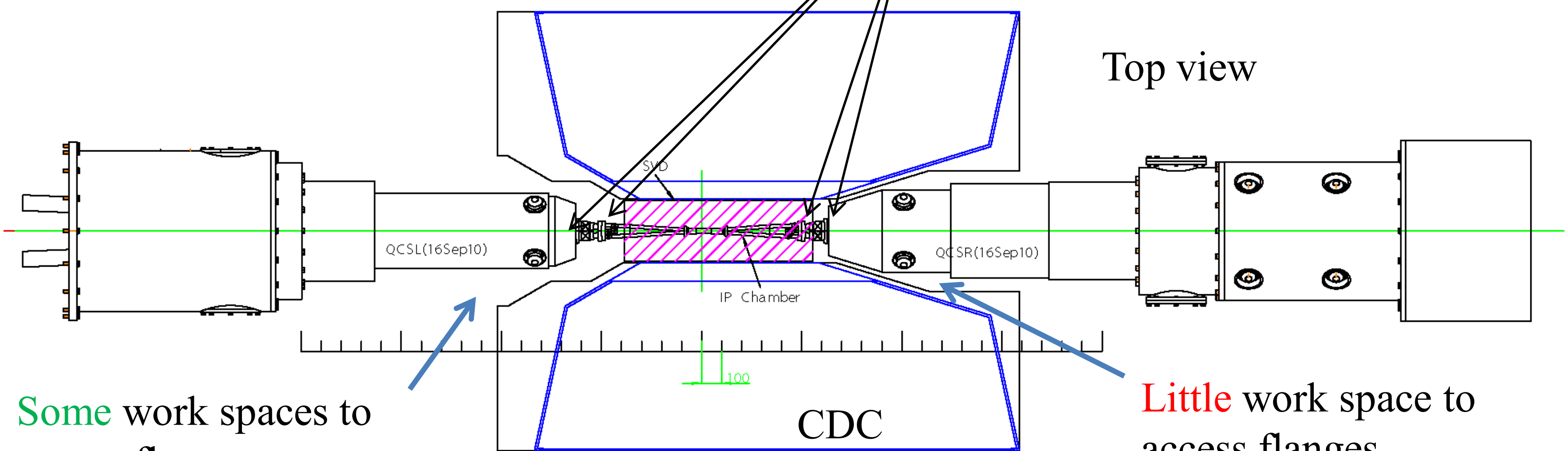


- The end of the bridge where QCS lies on is mechanically weak. For example the vertical oscillation of the place with 65 Hz is one of the lowest modes of the bridge oscillation.
- The measured amplitudes during KEKB are tolerable if QC1E and QC1P oscillate with the same phase (this is the most probable case).
- However. if a simple and effective way of reinforcement of this part is available, it should be done.
- The chance of the work is quite limited. The decision should be done as soon as possible.

Installation Scenario
Basic conditions

- IP chamber is supported by VXD frame.
  Both sides of IP chamber are fixed to the VXD frame transversally and are free longitudinally.
- VXD is supported by CDC.
  The R-side of VXD is aligned transversally and is free longitudinally.
  The L-side of VXD is fixed to CDC.
- QCS cryostats can move out.

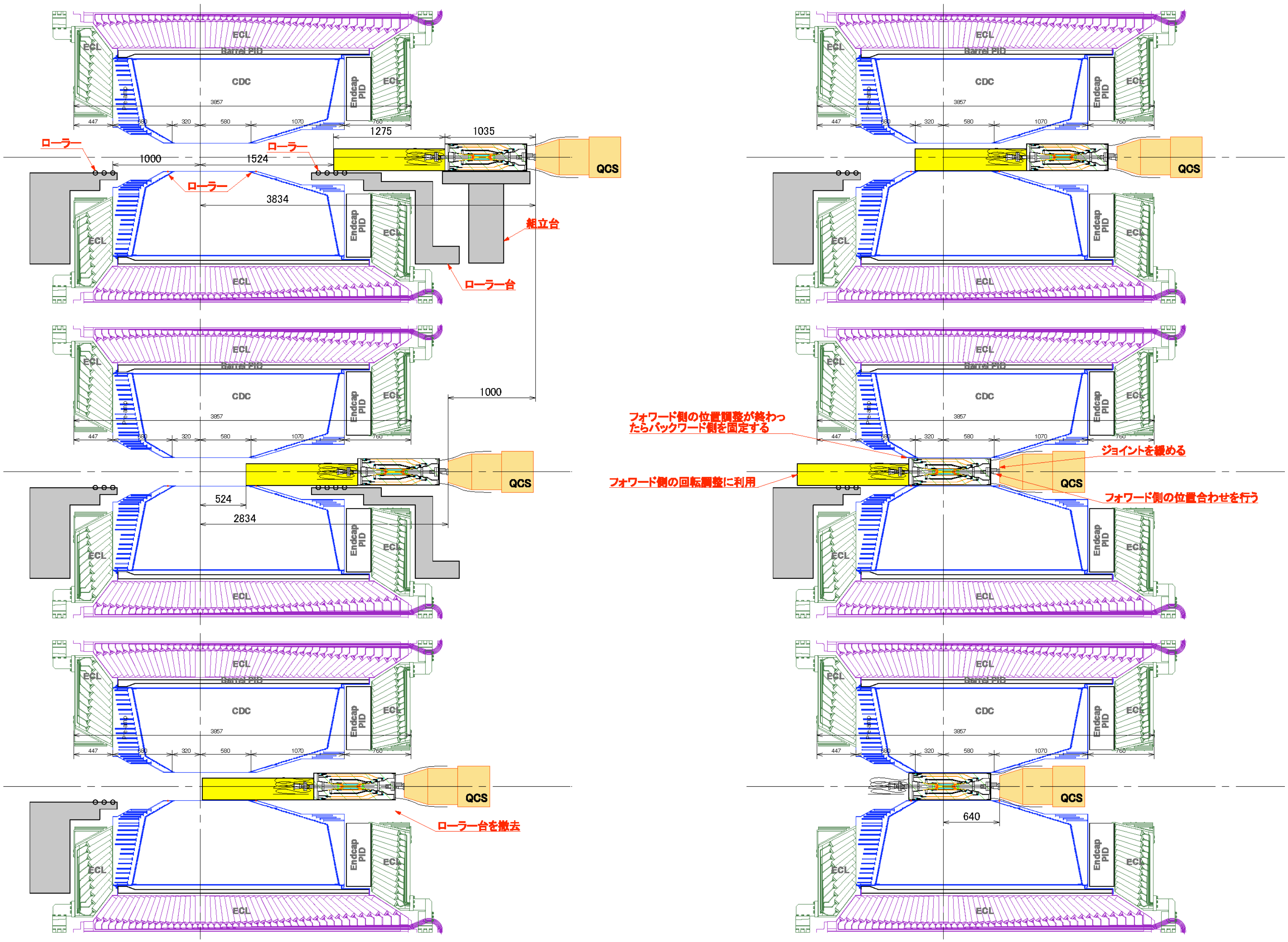
- Connection flanges for vacuum chambers.



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 by hands in this configuration.

Installation Scenario - Baseline

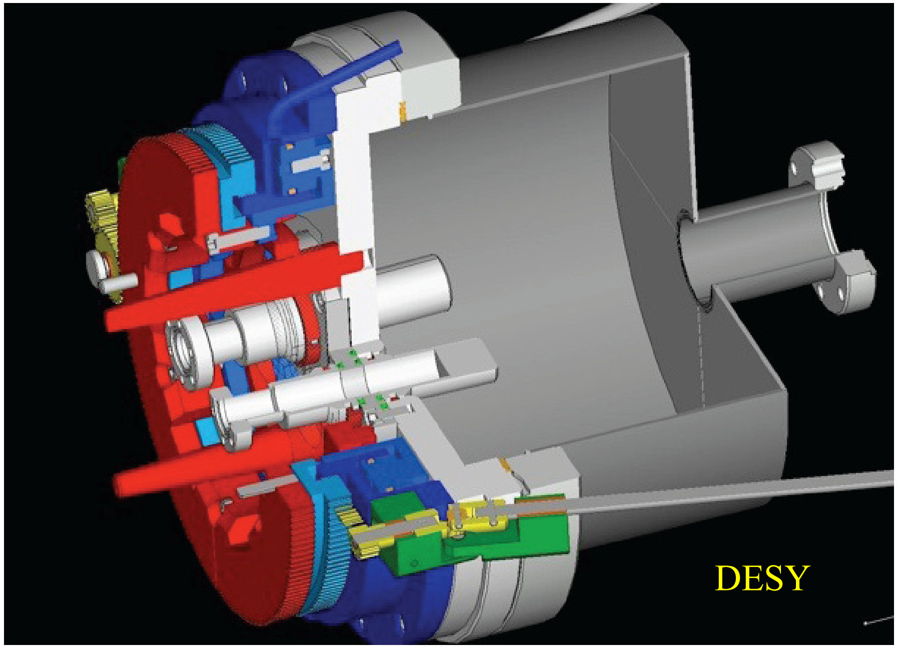


T. Kohriki

Installation Scenario

Alternative Scenario with Remote vacuum seal mechanism.

- Some people feel uneasy on the situation that VXD unit is pushed by QCS in the baseline scenario.
- They proposed an alternative scenario to slide VXD with manual force and a remote vacuum seal mechanism.
- The mechanism is not yet valid with a mock-up test.
- However the choice of the installation scenario has various impacts on detailed designs of VXD and surrounding components.
- The decision on the choice cannot be delayed so long.



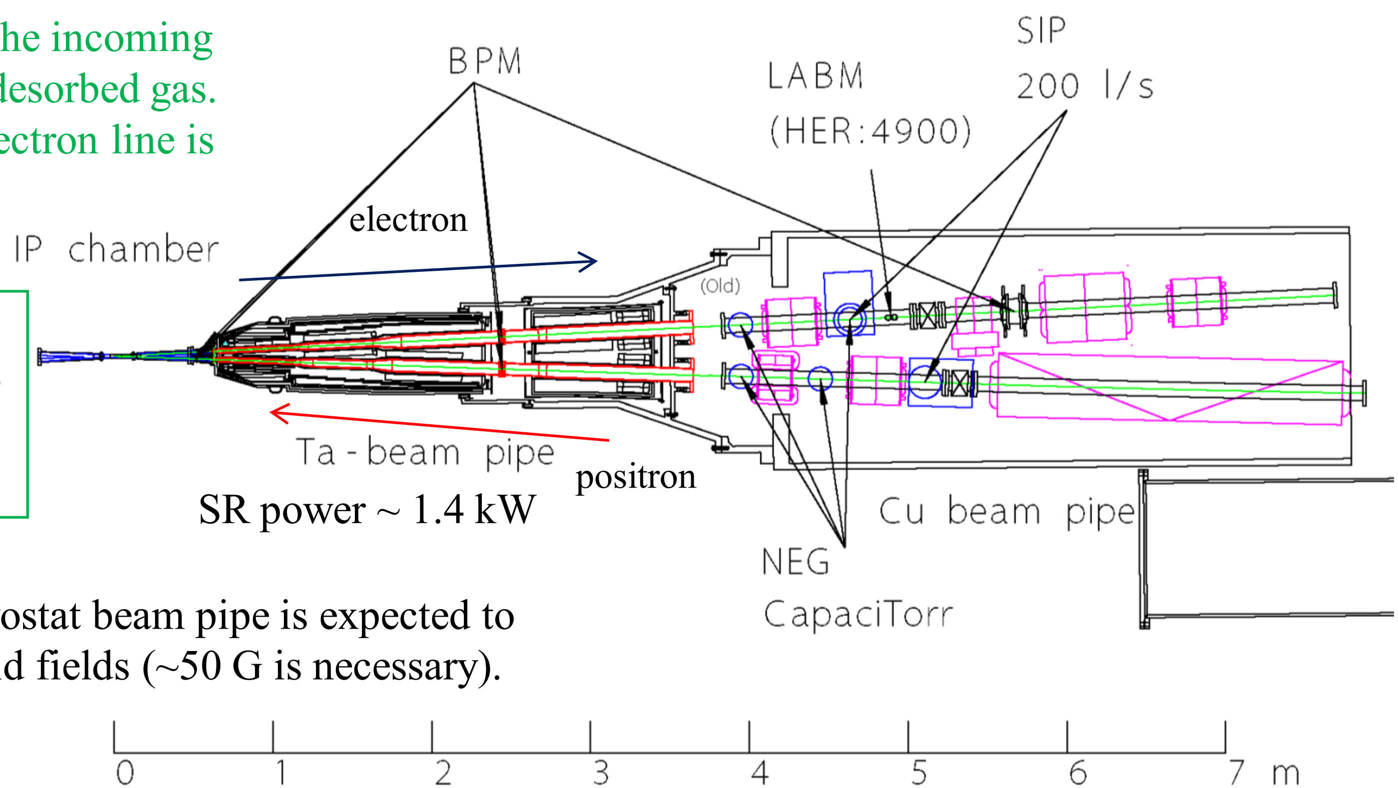
Vacuum around IR

Layout of vacuum components near QCS 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.

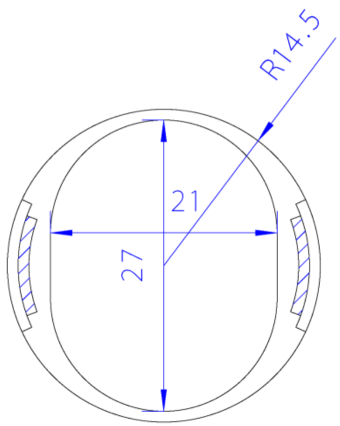
Ta beam pipes will be coated with Au or Cu to reduce ohmic power loss.



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

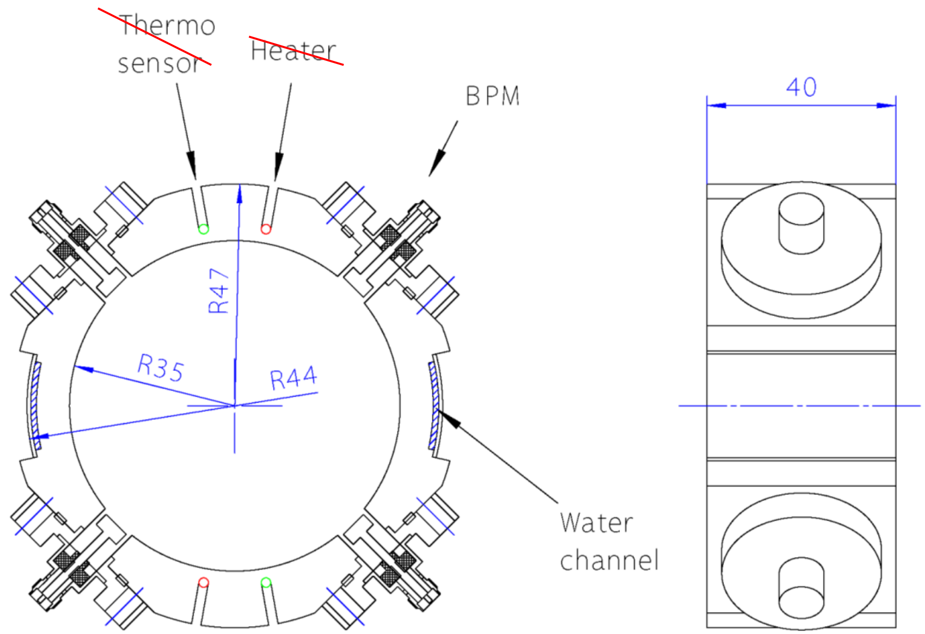
Vacuum around IR

Typical cross section of Ta beam pipe



Vertically elongated aperture in QC1P

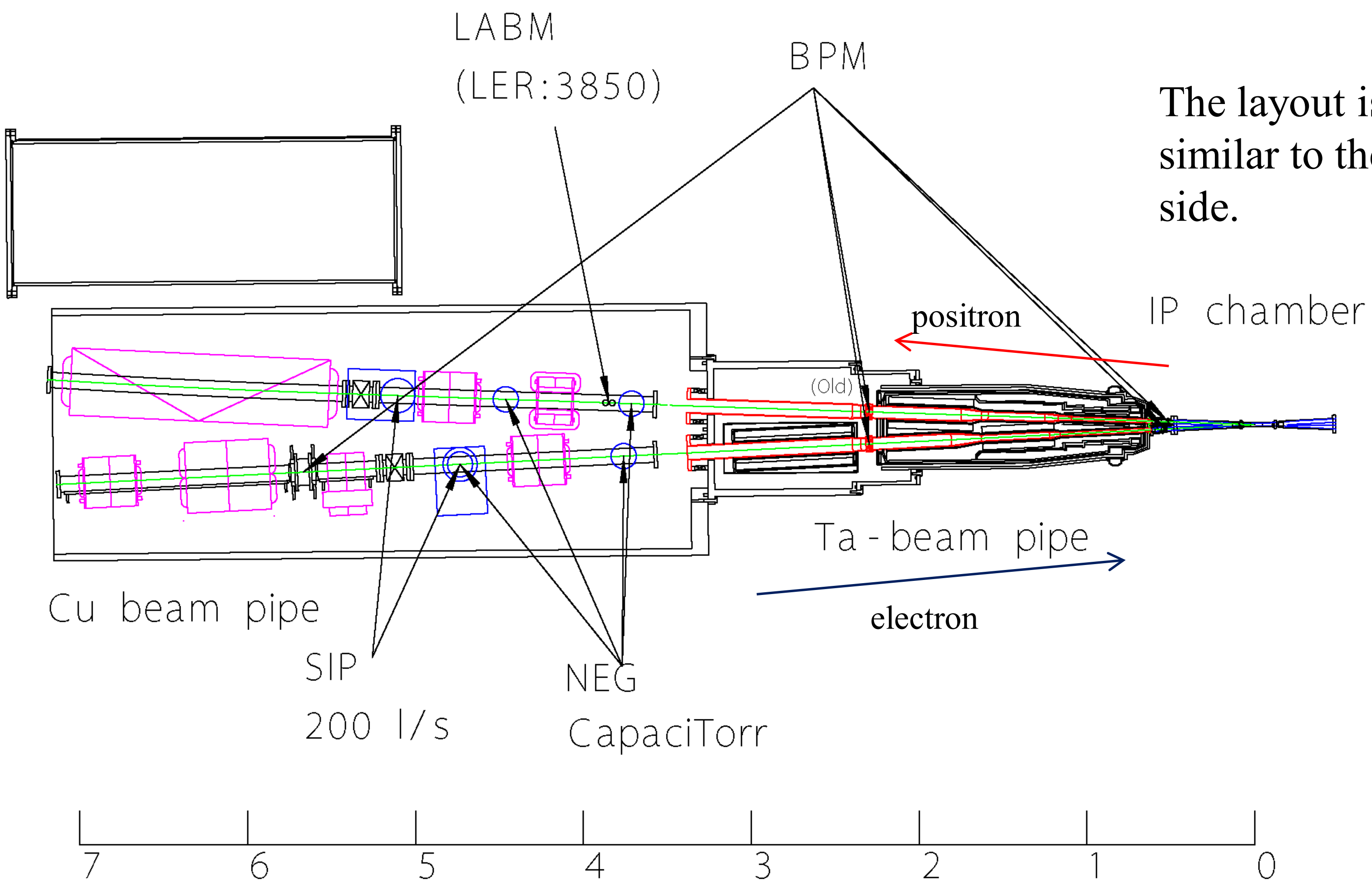
(Larger aperture is preferable but it is not available in the present design.)



BPM

Vacuum around IR

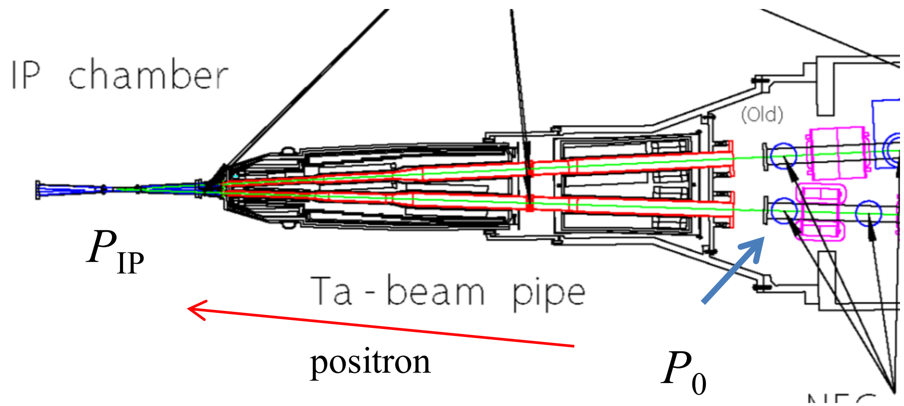
Layout of vacuum components near QCS in the L side



The layout is similar to the R side.

Vacuum around IR

Rough estimation of pressure near IP



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

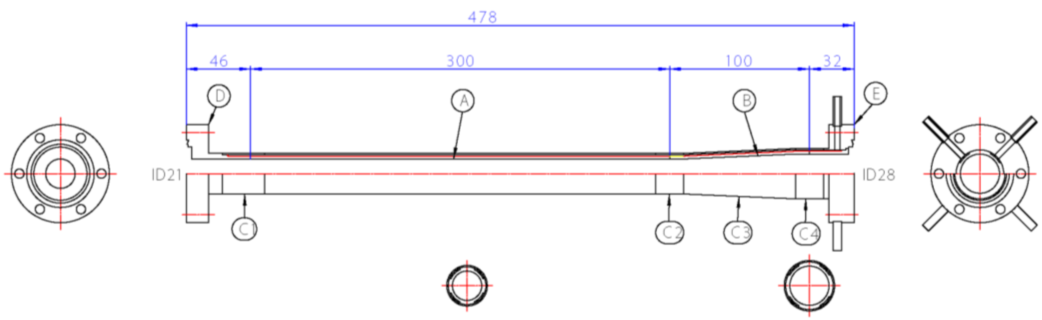
Assumptions:

- 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 (1.33×10^{-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.

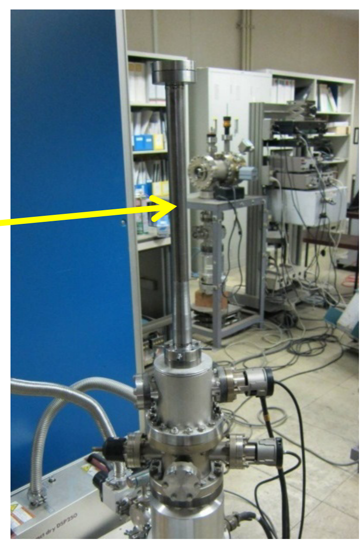
Vacuum around IR

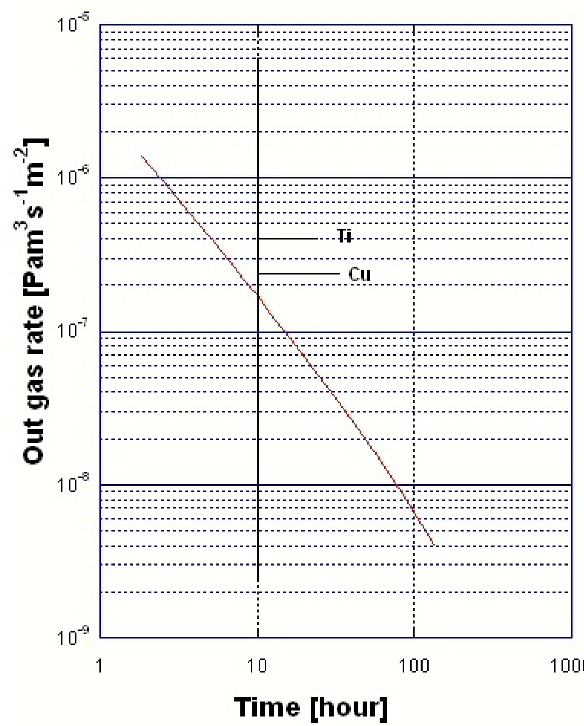
Test Ta beam pipe



A test Ta beam pipe with cooling channels, a taper, and conflat flanges was fabricated.

Ta pipe model for QCS with cooling path in the wall. This pipe has a weld seam between water and vacuum. The test with tap water caused no leakage at least for months.

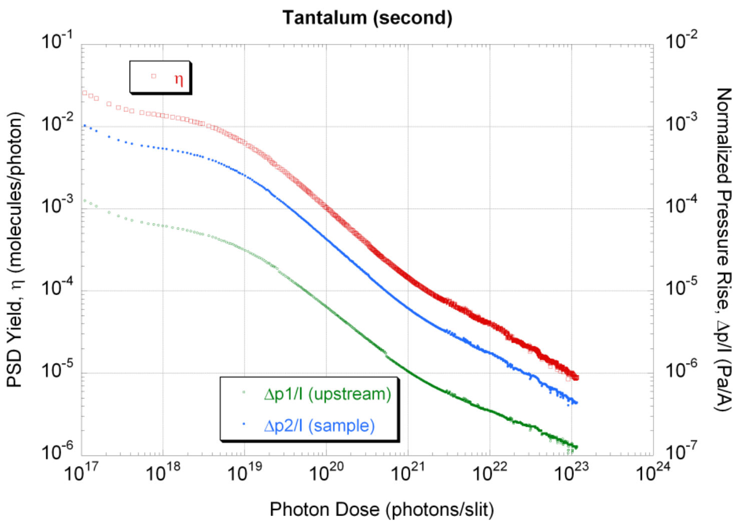


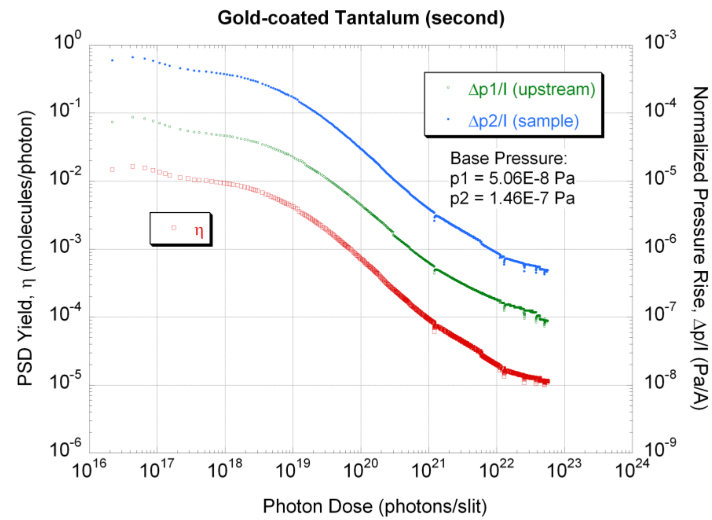


Thermal outgassing of the Ta pipe. 'Very low' (H. Hisamatsu)

Vacuum around IR

Photon-induced desorption of Ta, Au, and Cu (2^{nd})





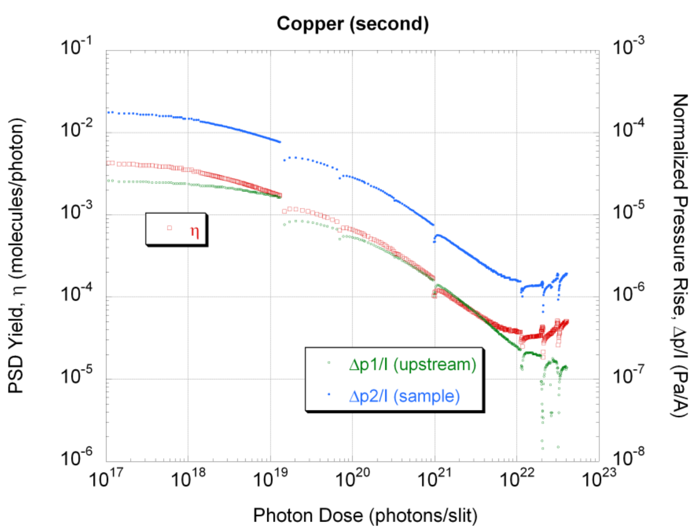


Photo-desorption coefficients of Cu, Ta, and Au-coated Ta. Ta and Au-coating have a sufficiently low photo-desorption coefficient.

(At PF BL21, $\varepsilon_{cr} = 4$ keV, by Y. Tanimoto)

Vacuum around IR

Consideration on IR pressure

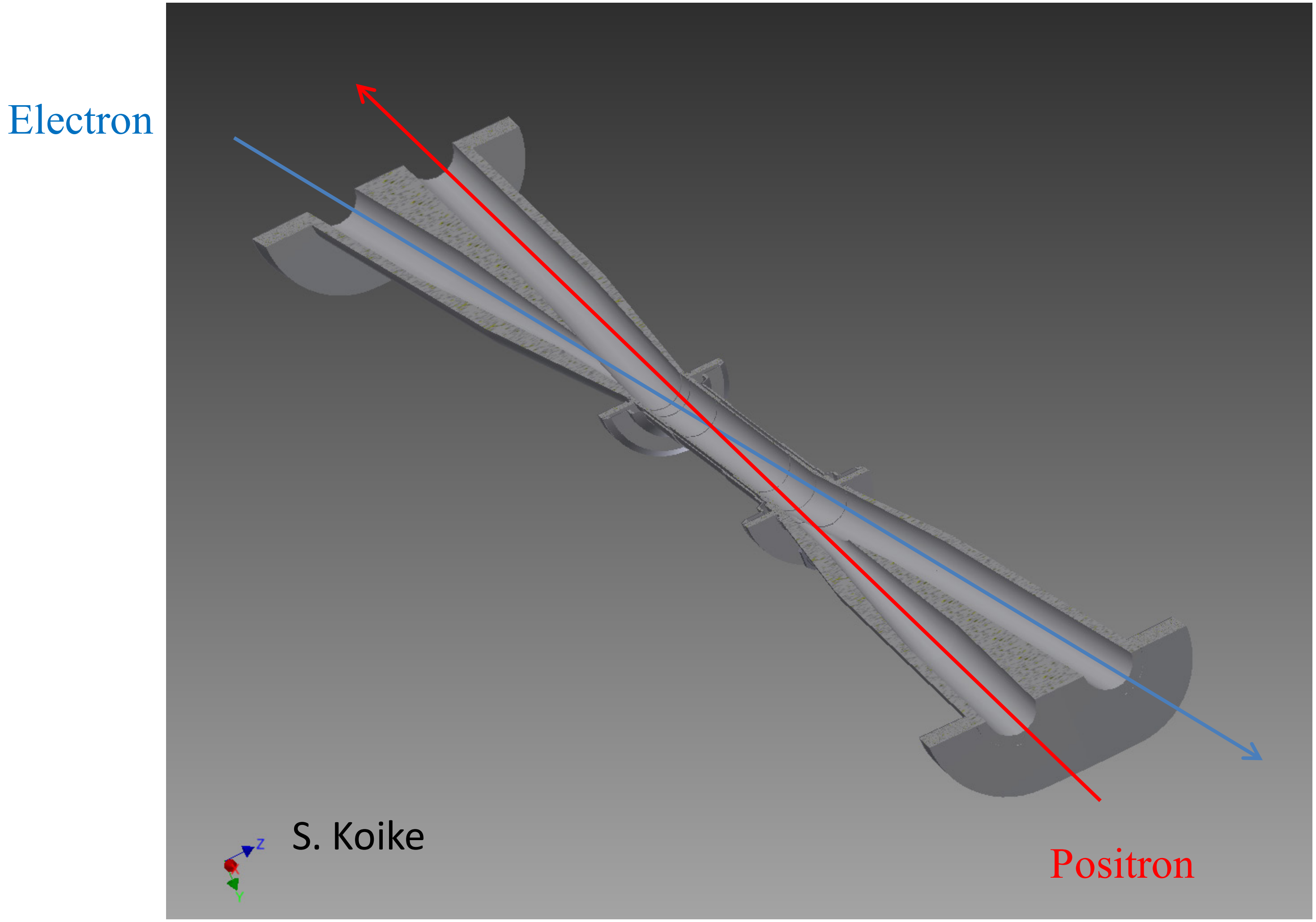
•At least, the pressure around the IP (±5m) must not affect the overall average design pressure of the ring (1×10^{-7} Pa). Therefore the target pressure in this region must be less than $1 \times 10^{-7} \times 3000/10 = 3 \times 10^{-5}$ Pa. A consideration on the beam-gas Rutherford scattering requires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

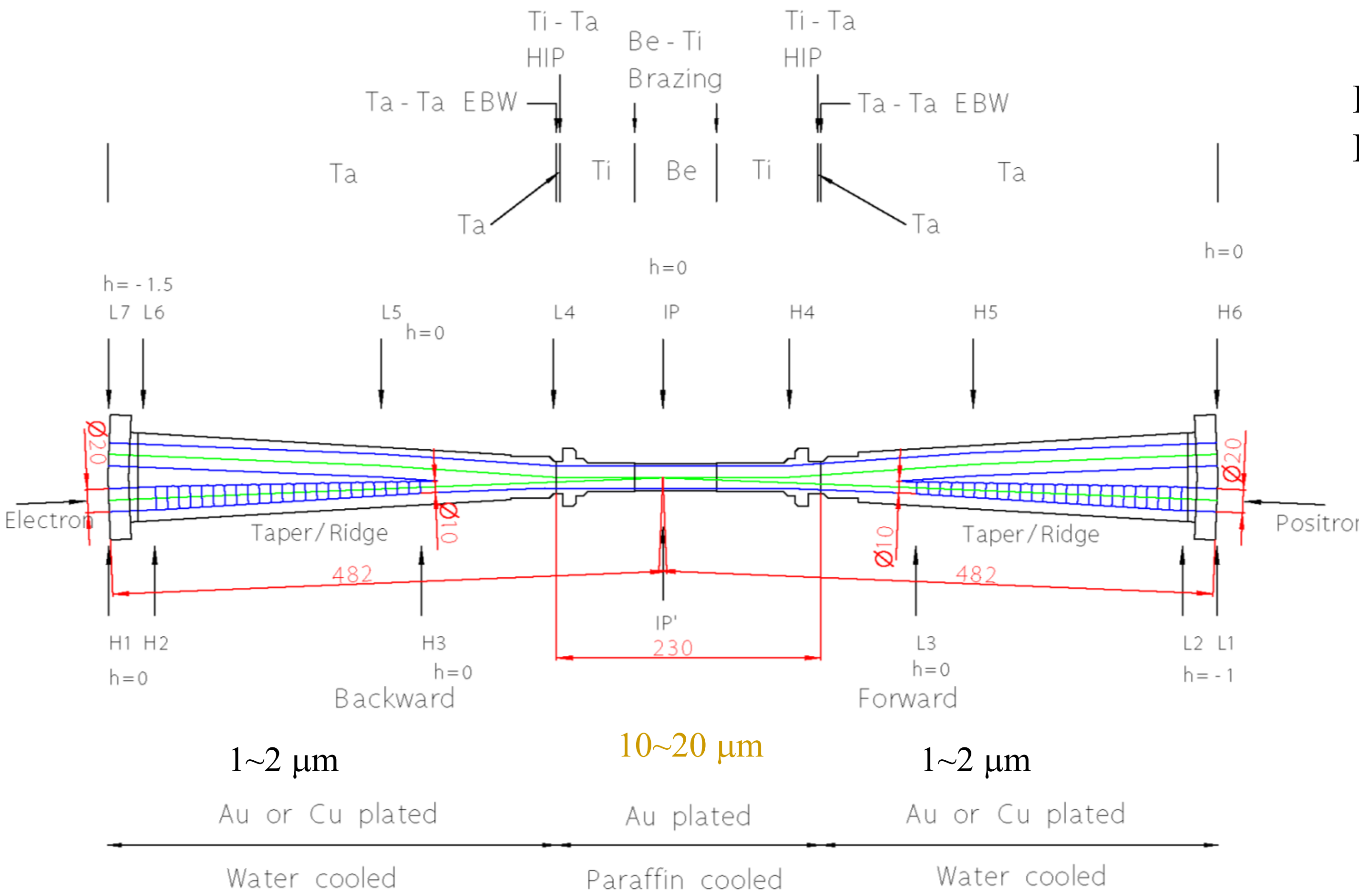
•It was shown that Ta and Au-coating have a sufficiently low photo-desorption coefficient. It was also shown Ta has a very low thermal outgassing rate.

•Still we are looking for an idea to improve IP pressure.

IP Chamber
Cut View



IP Chamber
Design feature



HIP = Hot Isostatic Pressing

- The central straight part consists of double tube. Paraffin runs between them.
- The connection between double tubes is done by Ti-Ti EBW.

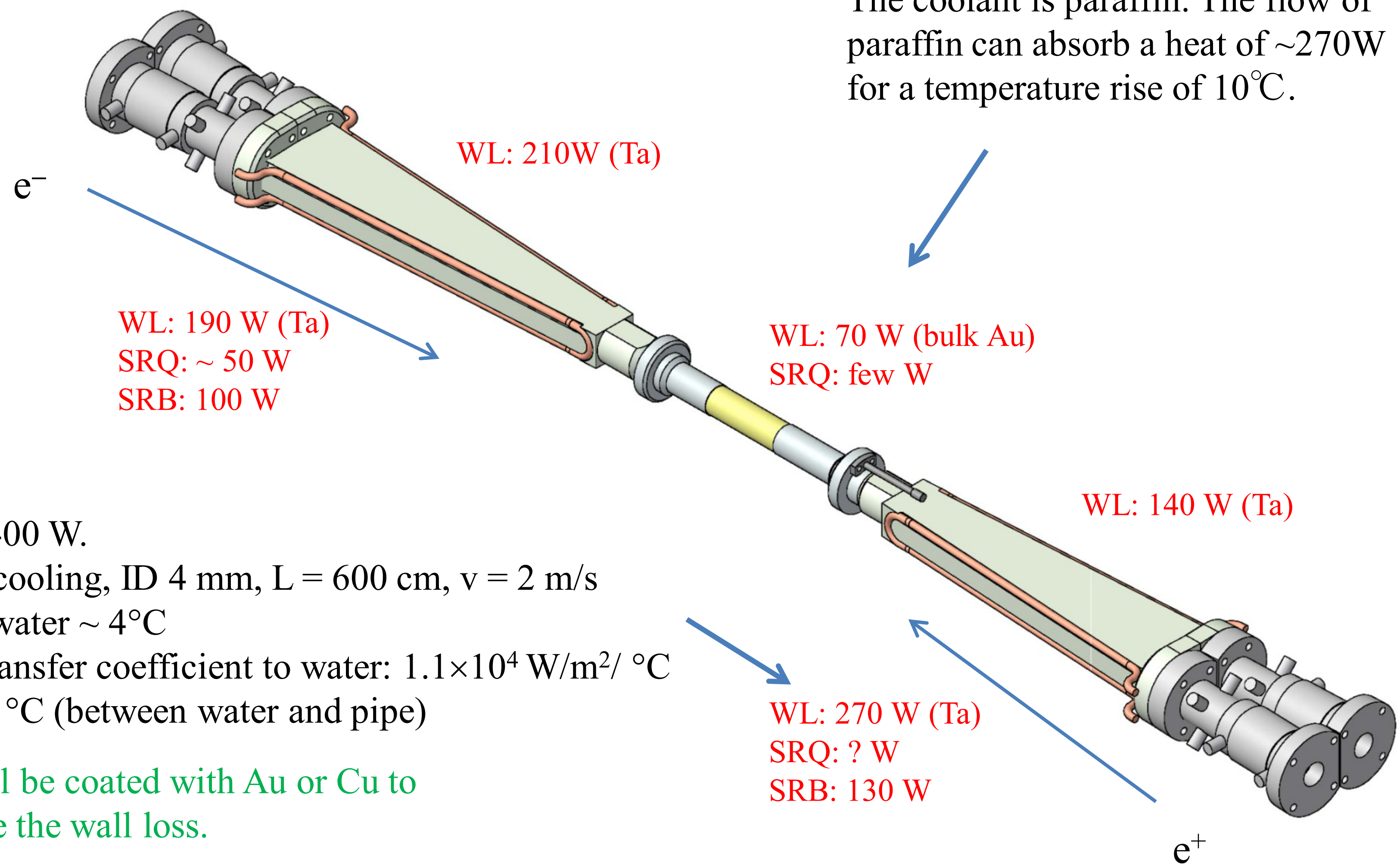
IP Chamber
R&D

- Done
  - Stress analysis
    - For the temperature difference between the two tubes at the center.
    - Changing support position of beam pipe
  - Fabrication test
    - Precise machining of Be pipes
    - NC machining of ridges
    - Be-Ti brazing
    - Ti-Ta HIP
    - EBW near by HIP
    - Pulsed sputter coating of Cu inside 2 cm Al pipe and its uniformity check
- To be done (in preparation)
  - Stress analysis
    - Check the strength under dynamic force
  - Fabrication test
    - Au coating on Ti pipe
    - Effect of EBW on the coating
    - Simulation welding between inner and outer Ti pipes
- Ta part will be fabricated in FY 2013 and the first version of IP chamber will appear within FY 2013

IP Chamber

Cooling

The coolant is paraffin. The flow of paraffin can absorb a heat of ~270W for a temperature rise of 10℃.



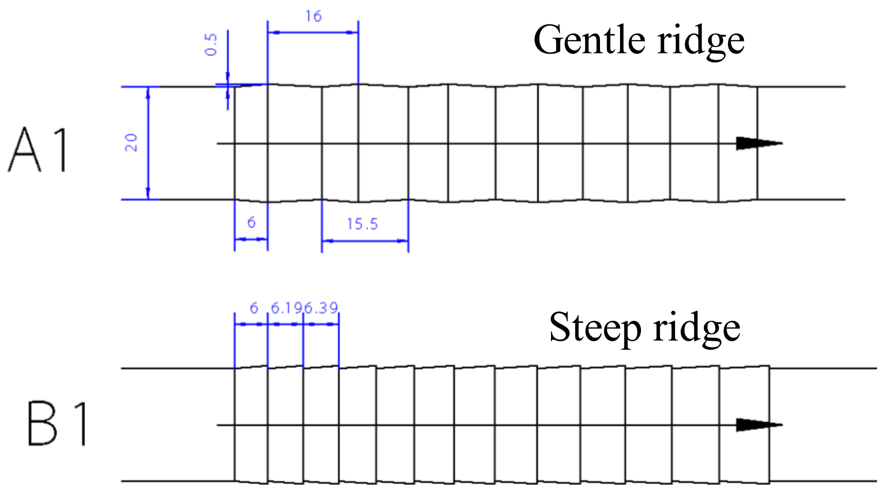
Heat: 400 W.
Water cooling, ID 4 mm, L = 600 cm, v = 2 m/s
ΔT of water ~ 4°C
Heat transfer coefficient to water: 1.1×10^{4} W/m^{2}/ °C
ΔT ~ 5 °C (between water and pipe)

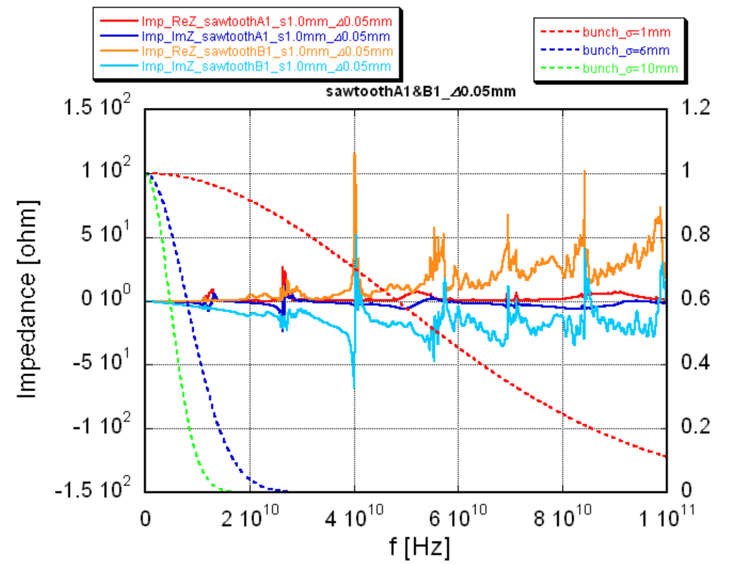
Ta will be coated with Au or Cu to reduce the wall loss.

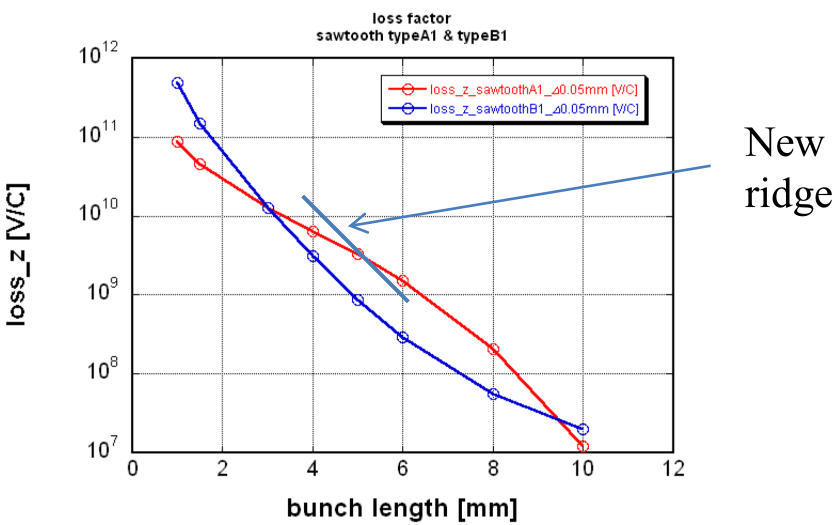
T. Kohriki

IP Chamber

Are steep ridges permissible?







Since the height of the ridge is only 0.5 mm, structures of impedance due to the sharpness of ridges appears in higher frequencies than a 6mm bunch spectrum.

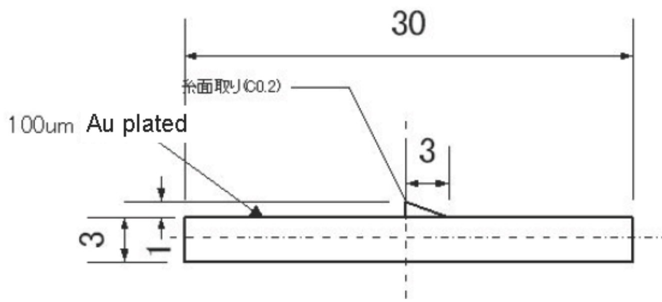
Steep ridges are OK.

(K. Shibata, Y.H. Chin)

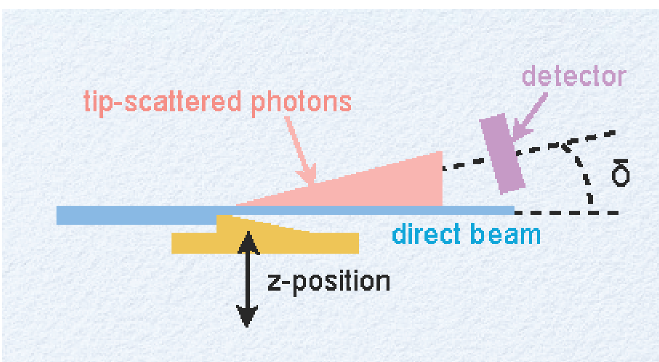
IP Chamber

Tip scattering on a ridge

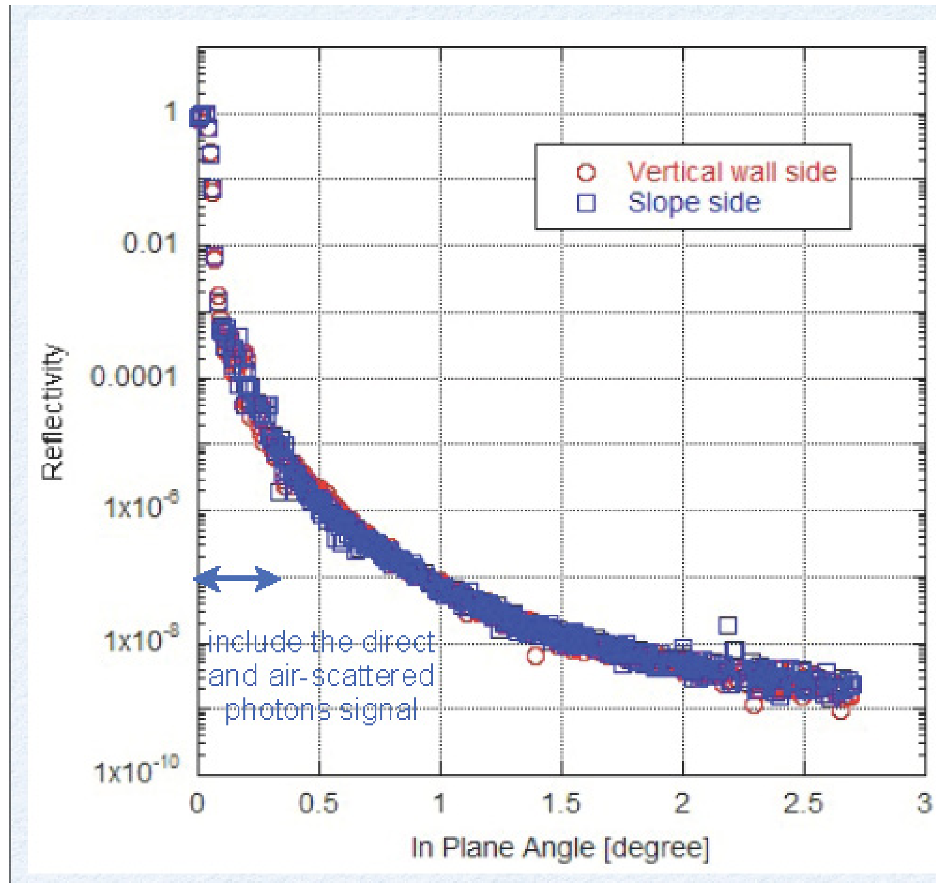
T. Ishibashi, et al



Ta sample



Set up

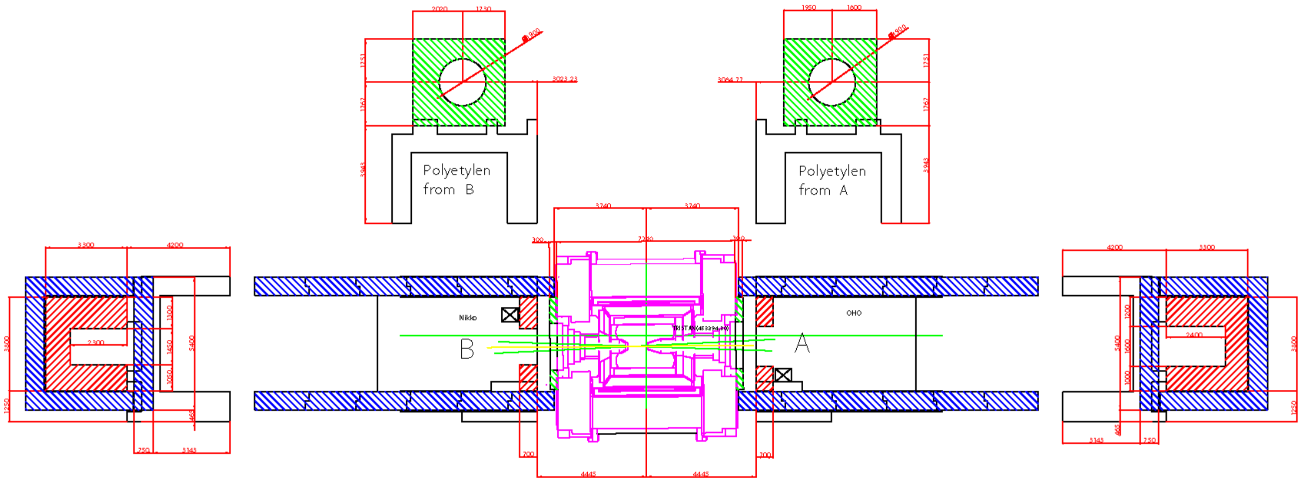


CHESS (Cornell Univ.) G2 beam line
Photon energy : 9 keV
Slit : 2 mm (H) by 0.05 mm (V)
Detector angular resolution : 0.2 degree (FWHM)

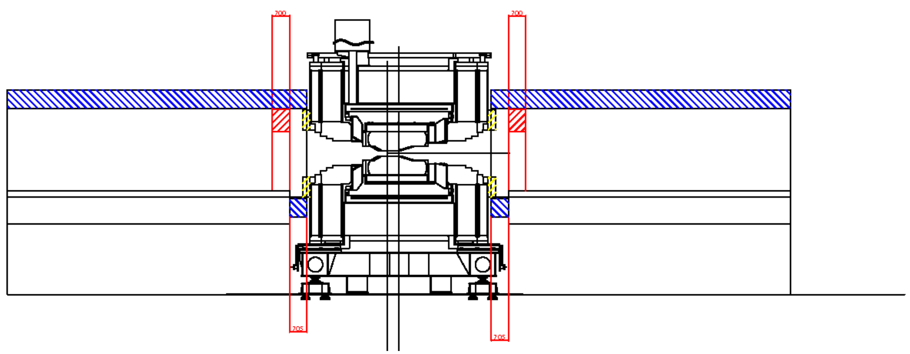
Ratio of the scattered photon. The slope of the taper inside the pipe is 1.23 degree.

Radiation shield

Phase 2

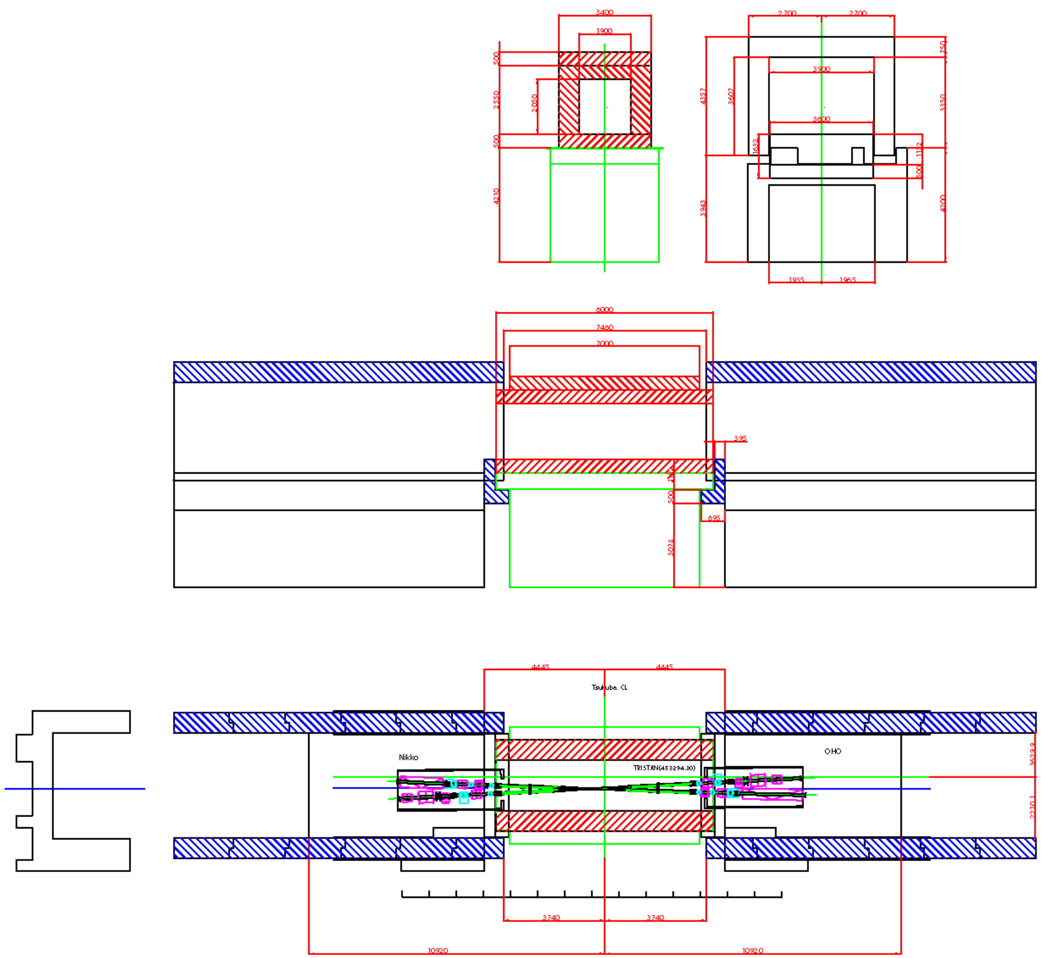


There are two major radiation sources in the interaction region. One is the LER horizontal collimator (upstream) to cut the halo created by Touschek effect. The other is the downstream LER beam pipes hit by off-momentum positrons and gamma rays due to the radiative Bhabha process. (Y. Funakoshi, Y. Ohnishi)



The present design seems insufficient to keep the experimental hall free from radiation.
(H. Nakayama and T. Sanami).
Further investigation is necessary.

Radiation shield
Phase 1



Now on-going estimation of the beam loss at phase 1 suggests this structure is sufficient for Phase 1.
(Y. Ohnishi, T. Sanami)

Summary

- With the progress of the construction of SuperKEKB, the number of tasks to be solved for the interaction region is increasing.
- Among them,
  - We must make decision on the bridge reinforcement as soon as possible.
  - The choice of the installation scenario has verious side effects. It cannot be delayed so long.
- And,
  - We are still looking for an idea to improve IP pressure.