Interaction Region Mechanicals Overview

20th KEKB Accelerator Review Committee
KEK, 23-25 February 2015
Ken-ichi Kanazawa
for
KEKB Vacuum Group
IR Technical Meeting Member
IR Installation Meeting Member
SVD/IR Mechanics Meeting Member

Contents

- Addressing the last committee report
- Preparation toward Phase 1
- Issues for Phase 2 and later
- Summary

19th KEKB Accelerator Review Committee Report

Executive summary

Recommendations:

4) The SuperKEKB/Belle II interaction region IR is extremely complex and the Committee recommends continued attention to the issues of the beam-beam interaction, beam lifetime, superconducting magnets, vacuum pressure, backgrounds, assembly, and machine detector interfaces.

Reply:
We continue our efforts.

19th KEKB Accelerator Review Committee Report

Findings and comments (Pressure of IR)

Concerns:

There is no vacuum pumping over +/-4 m as agreed to by the Belle II detector as there is no space for internal or external pumps. The potential use of a vacuum simulation code is recommended to predict the vacuum profile in the IR region. This would be a good task for a young vacuum person leading to an optimized choice of vacuum pumping outside the IR beyond 4 m. The calculation of the pressure profile during the scrubbing phase profile is also very important to predict the validity of the concrete shielding. The simulation should take into account also methane degassing: the nearest pump to the interaction point has a very low pumping speed for CH_4. The indication that 'the average pressure in the IR region will be 10^{-6} Pa or higher' should be further investigated in detail with the hope of understanding the maximum pressure and making it as low as possible and consistent with Belle II operation. (See the next slide)

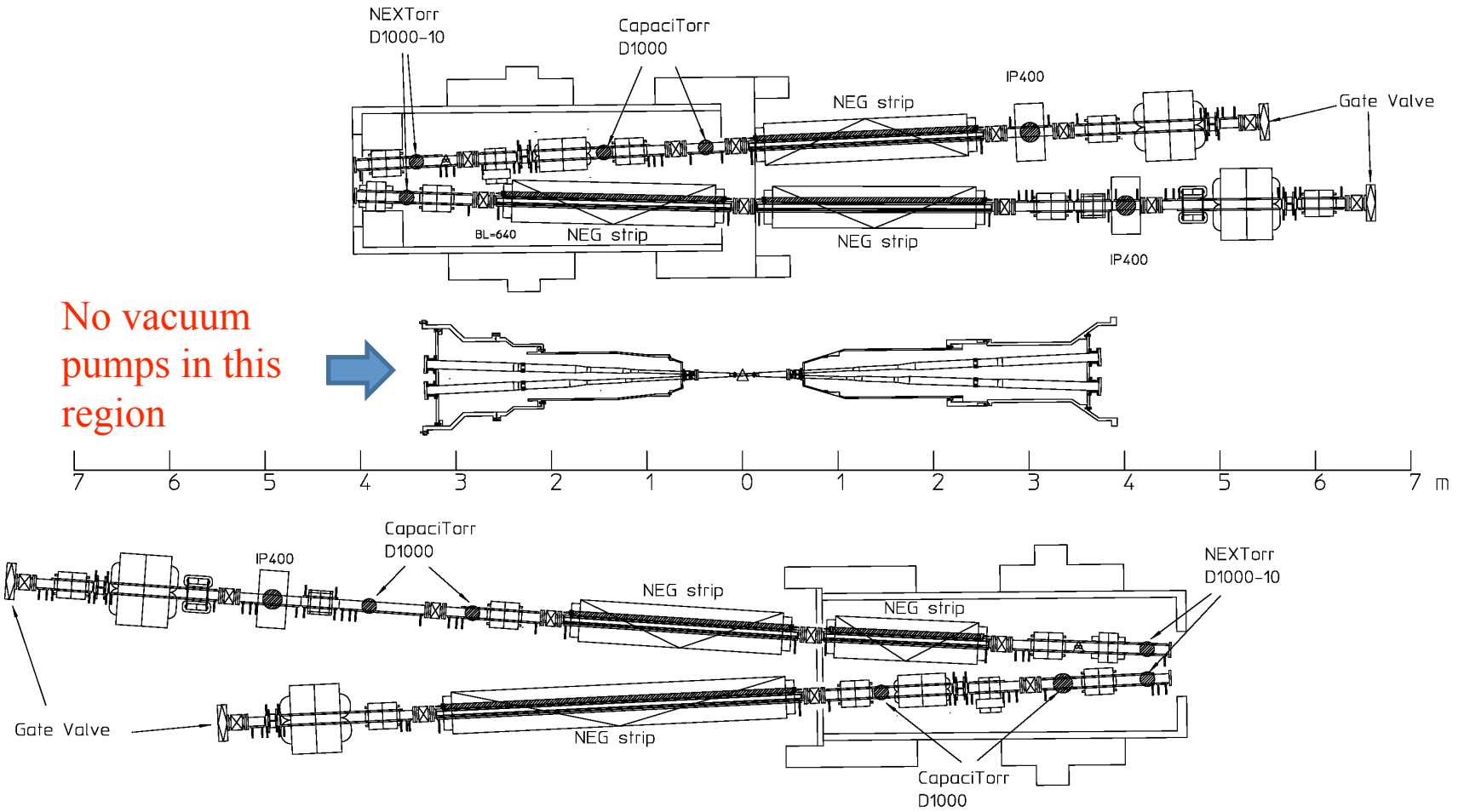
Recommendation:

New calculations of the expected vacuum pressures in the IR should be completed including the new chamber geometry, surfaces, and beam conditions.

Reply:

I agree the importance to investigate a pressure profile near IP. I made contact with R. Kersevan and M. Ady. I also attended the Molflow seminar by M. Ady held at KEK. We agreed to study somewhat simplified IR model. However, I have not yet prepared necessary data, because of the complexity of IR geometry. I think we should get some results until Phase 2 (not an urgent issue).

Vacuum system of IR



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Findings and comments (Electron cloud in IR)

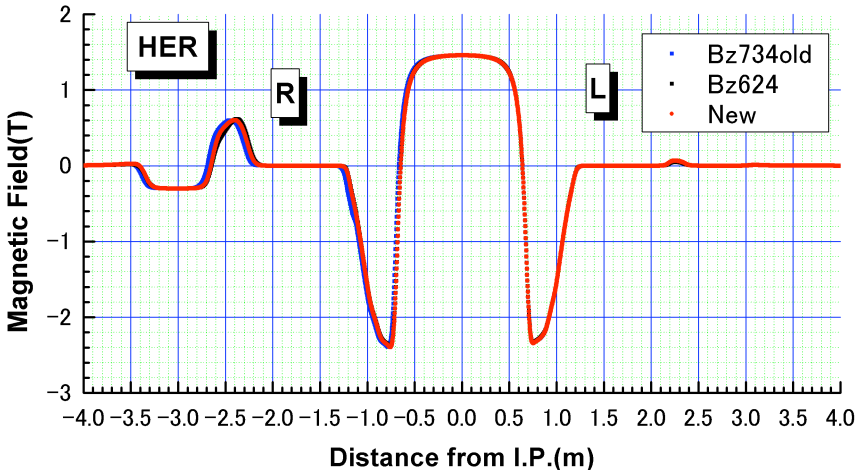
Concerns:

In the present design, there is no TiN coating in the IR region. It is not clear if scrubbing would be as efficient as in the rest of the accelerator. It is also not clear where solenoids could be installed in case electron cloud appeared in the IR chambers.

Reply:

For Phase 1, all positron beam pipes are TiN coated. Since the stored current at Phase 1 is 0.5 – 1 A. This is sufficient.

For later Phases, there is always a certain kind of magnetic fields. If we see a solenoid component, it is strong enough to suppress the cloud. However, simulation under the real complicated field pattern will be necessary to estimate a real density of the cloud. The effect of the cloud in a large beta-function region is large.



H. Yamaoka

19th KEKB Accelerator Review Committee Report

Findings and comments (RVC)

Concerns:

A productive collaboration has been made with a group at DESY to explore the "remote vacuum connection". A good solution is not yet defined. It is not clear when a decision will be taken and on which criteria.

Recommendation:

Perform laboratory tests on the reliability of the "remote vacuum chamber connection" under vacuum conditions.

Reply:

AIM with RVC was approved at 18th B2GM (18-21 June 2014).

For more on RVC, see later slides.

Findings and comments (Residual activation)

Concerns:

The Radiation Control Group should evaluate whether the larger backgrounds in the IR with SuperKEKB will lead to significant residual activation of the IR vacuum chambers. A possible consequence could be that if the IR region vacuum chambers need to be worked on, they may be too activated to quickly initiate a repair.

Reply:

For an electron collider, residual activation around IP is not serious compared to hadron colliders. Rather, radiation damage on detector components is an important issue. Radiation dose on the detector components is repeatedly estimated along with the estimation of beam background.

19th KEKB Accelerator Review Committee Report

Findings and comments (QCS beam pipes)

Recommendations:

Finalize the vacuum chamber designs for Phase II within 4 m of the IP and proceed with engineering.

Reply:

See later slides.

Preparation for Phase 1 (early 2016)

Gate shield
(Oct.-Nov. 2015)

New shield wall (Sep. 2015)

New shield wall (Sep. 2015)

LABM: July
Beast 2: September?

All beam pipes will be installed and connected till the end of June, and will be pumped down.

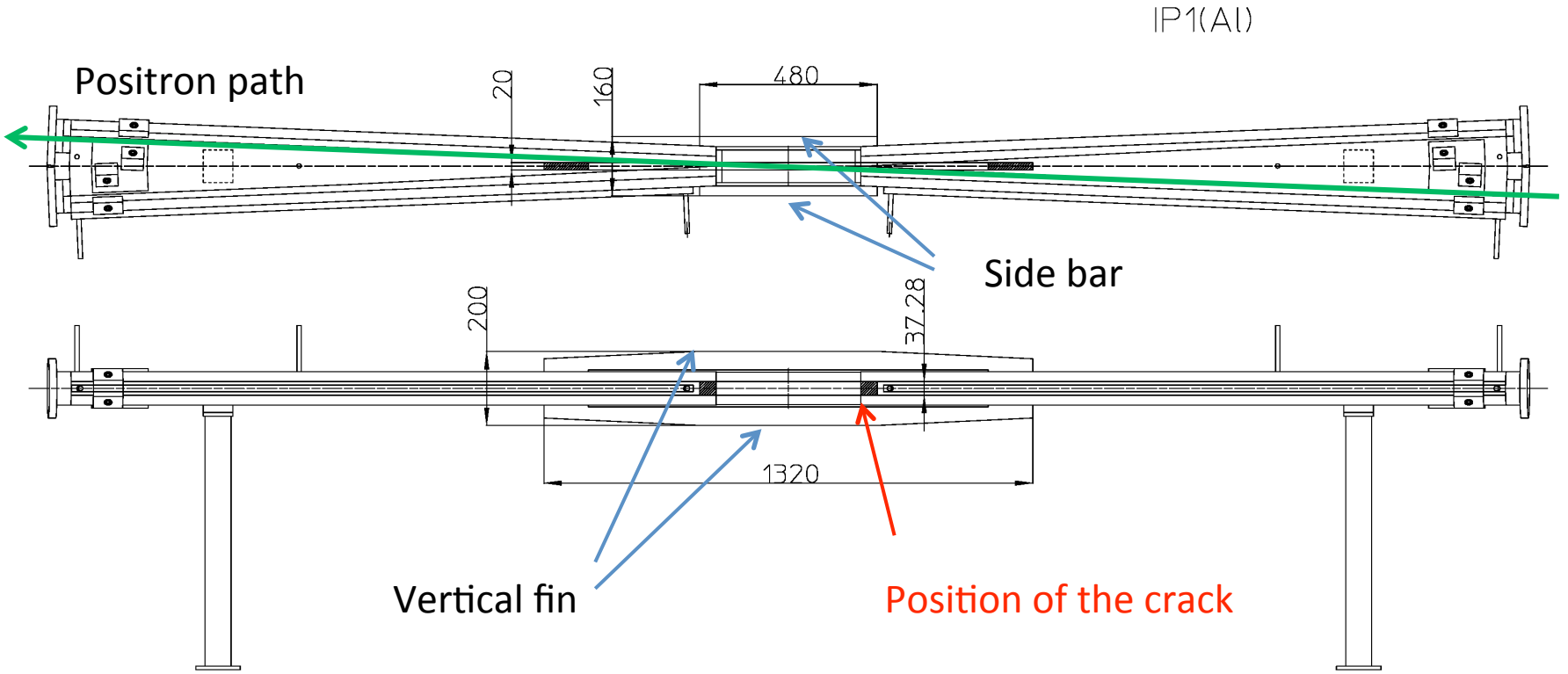
IP shield
(Oct.-Nov. 2015)

Preparation for Phase 1

Reinforcement of IP1 chamber

The central chamber for Phase 1 IR, IP1, developed a crack on a weld seam during preparation for TiN coating (K. Shibata).

The chamber will be re-welded and vertical fins and side bars will be attached for reinforcement. The work will complete before 19 June 2015.



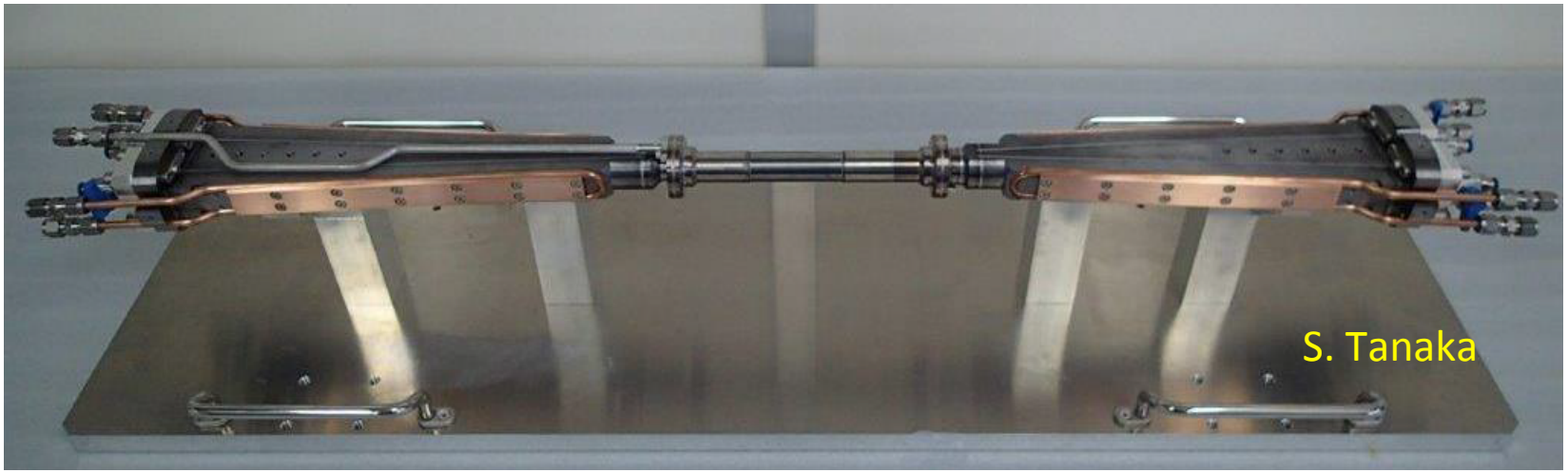
Issues toward Phase 2 and later

- QCS issues, fabrication, field measurement, and cables (N. Ohuchi and Magnet group)
- IP chamber
- RVC (Remote Vacuum Connection)
- Beam pipes for QCS

Issues toward Phase 2 and later

IP chamber

The IP chamber for Phase 2 is completed. However, without feedback from Phase 2 experiences, the next chamber for Phase 3 must be fabricated.

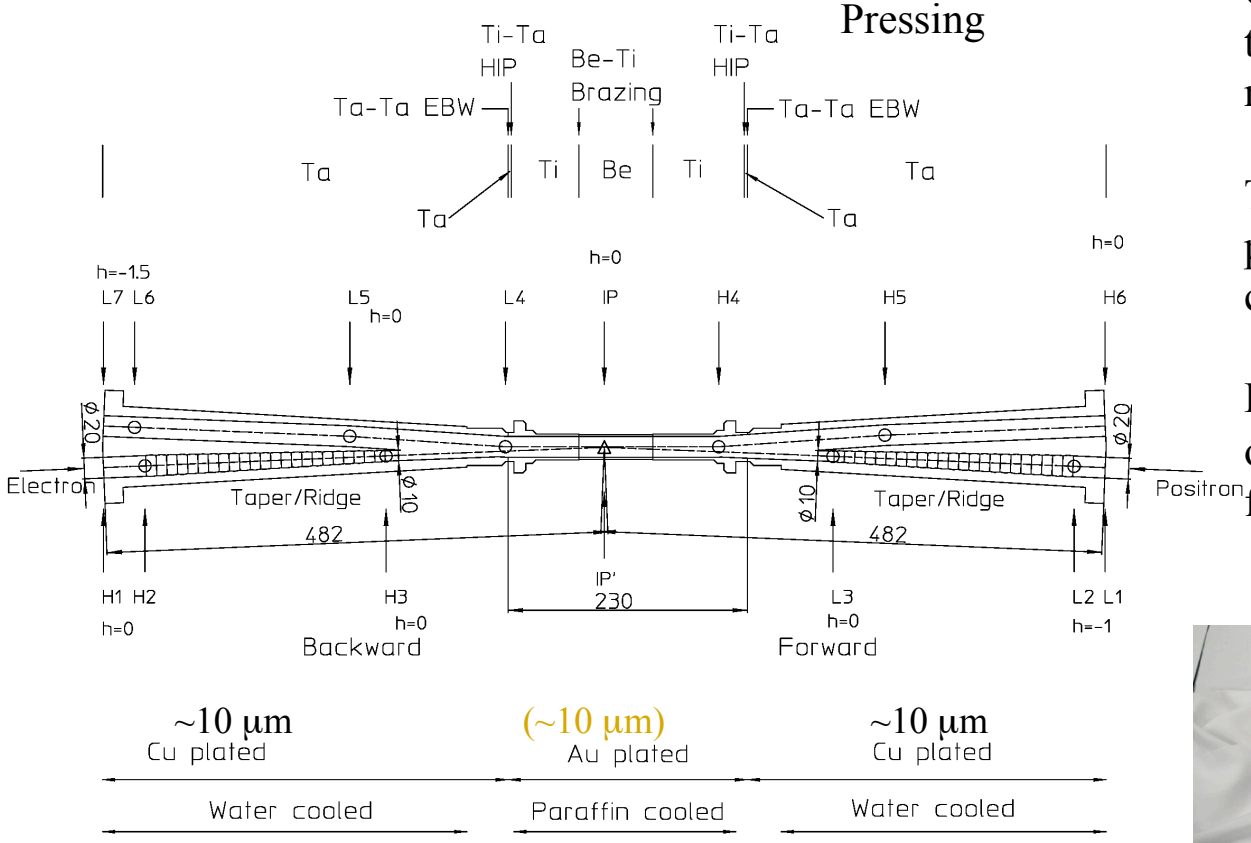


Early 2018: The installation of VXD starts.
Early 2017: The assembly of VXD and its cosmic-ray test must start.
May 2017: Phase 2 run starts.
Therefore the next IP chamber mast be produced before Phase 2. Already, machining of Ta part was over. Comments on the present design are welcome.

Issues toward Phase 2 and later

IP chamber: Design feature

HIP = Hot Isostatic Pressing



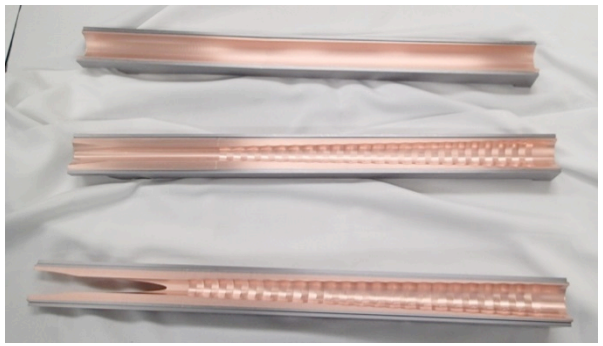
Negligible trap of HOM at the central part.

Only taper parts are exposed to direct synchrotron radiation from the last bend.

Taper: to reduce the number of photons entering into the central part

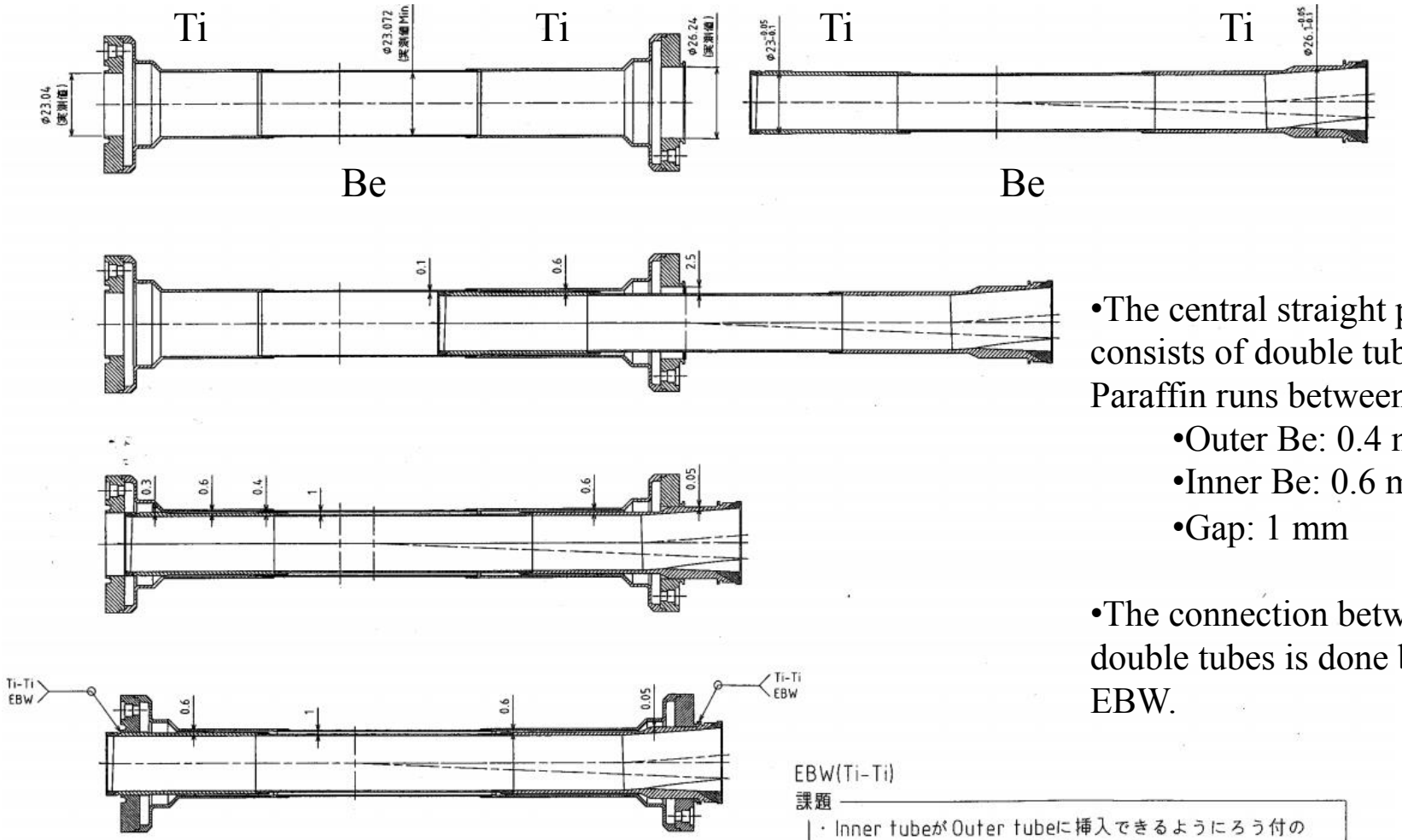
+

Ridges: to keep the direction of scattered photons away from Be



Issues toward Phase 2 and later

IP chamber :Central part



- The central straight part consists of double tube. Paraffin runs between them.
  - Outer Be: 0.4 mm thick
  - Inner Be: 0.6 mm thick
  - Gap: 1 mm

- The connection between double tubes is done by Ti-Ti EBW.

EBW(Ti-Ti)

課題

- Inner tubeがOuter tubeに挿入できるようにろう付の精度を上げると共に寸法公差の見直し。
- EBW施工時にベリリウムに負荷が加わらない治具の検討。

Issues toward Phase 2 and later

IP chamber: Underlying studies

- Related works performed for the design and production of IP chamber
  - Cooling test of the central part using a dummy model
  - Mechanical analysis
  - Impedance estimation
  - Measurement of tip-scattering of photon on a ridge
  - Photon-induced desorption measurement of Au coat, Cu, and Ta
  - Estimation of SR background inside chamber
  - DC sputter coating test
  - HIP and welding test under various conditions
- Ref.

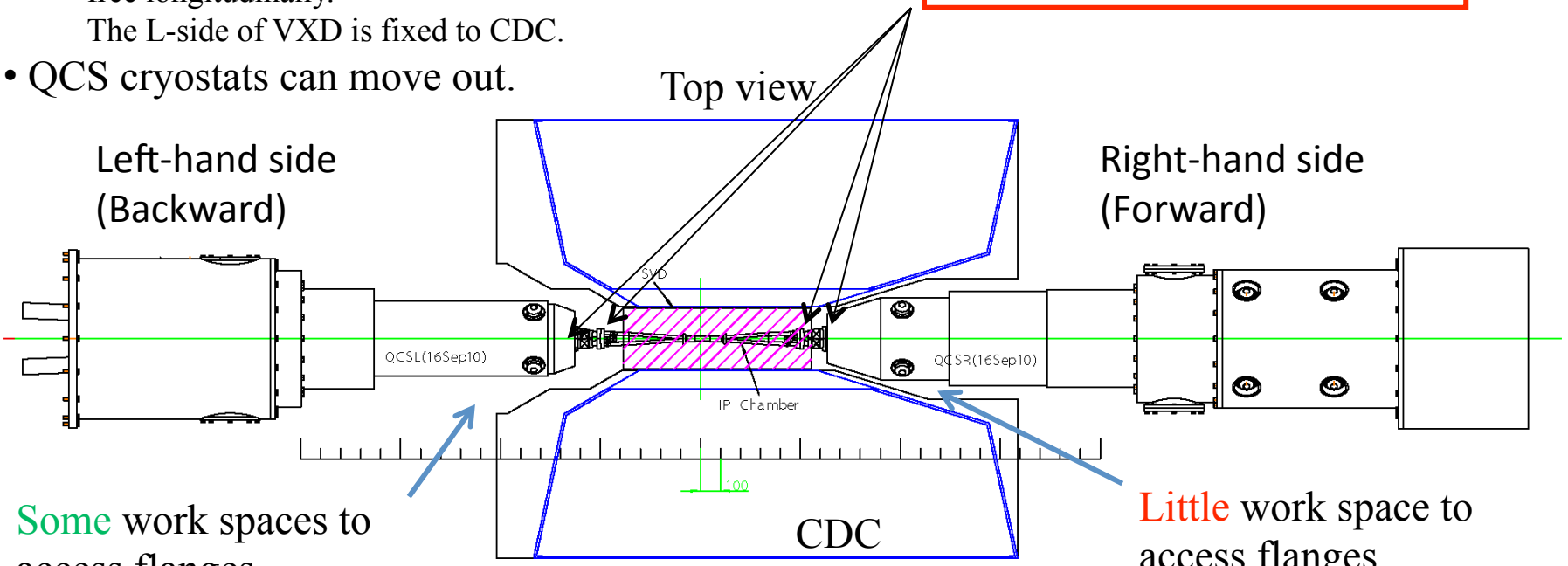
K. Kanazawa, The 18th KEKB Accelerator Review Committee, KEK, 4-6 March 2013,
K. Kanazawa, 7th Belle PAC, 10 -11 March 2013, KEK

Issues toward Phase 2 and later

RVC : Where to use

- 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.

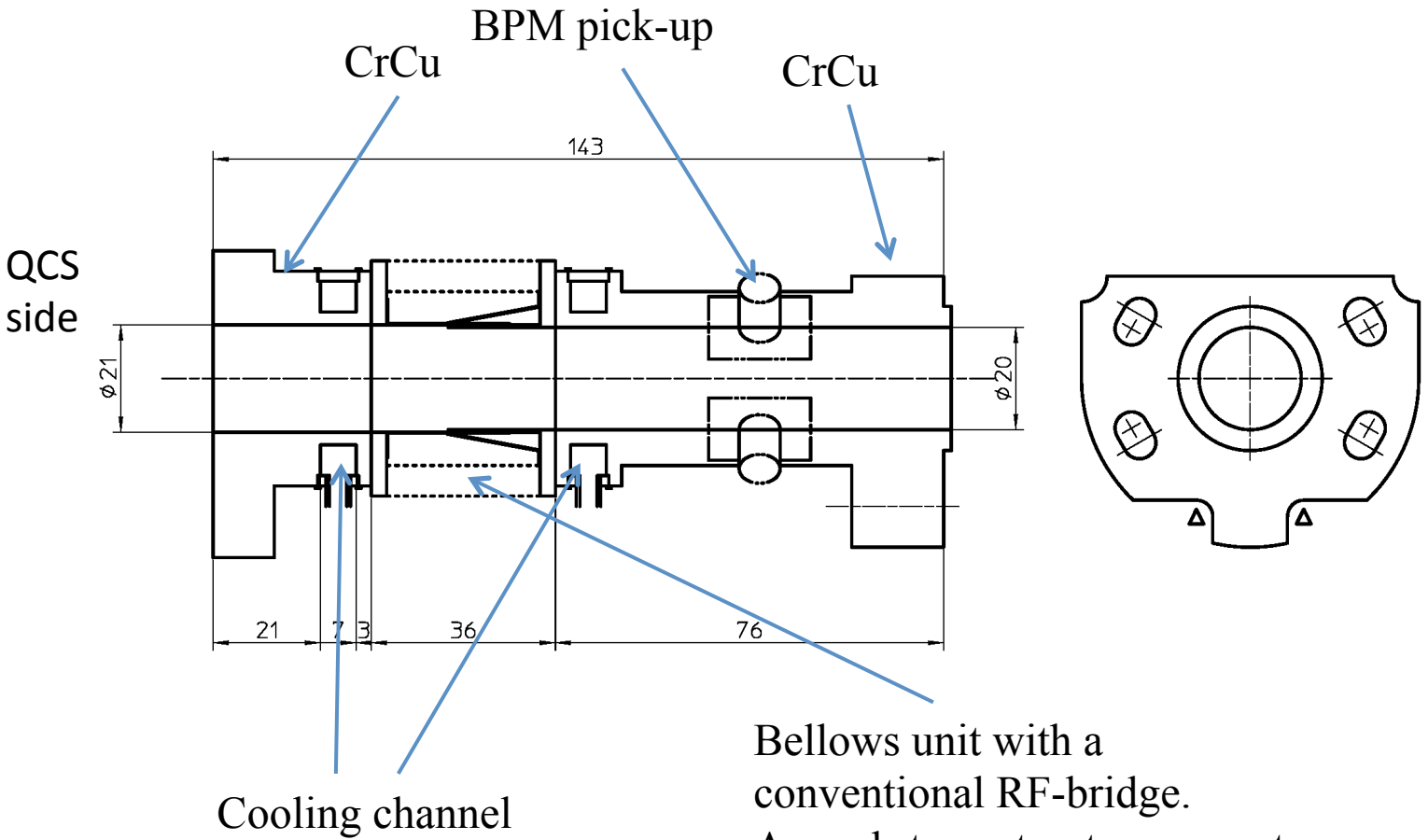


Some work spaces to access flanges.
It will be possible to make use of these spaces.

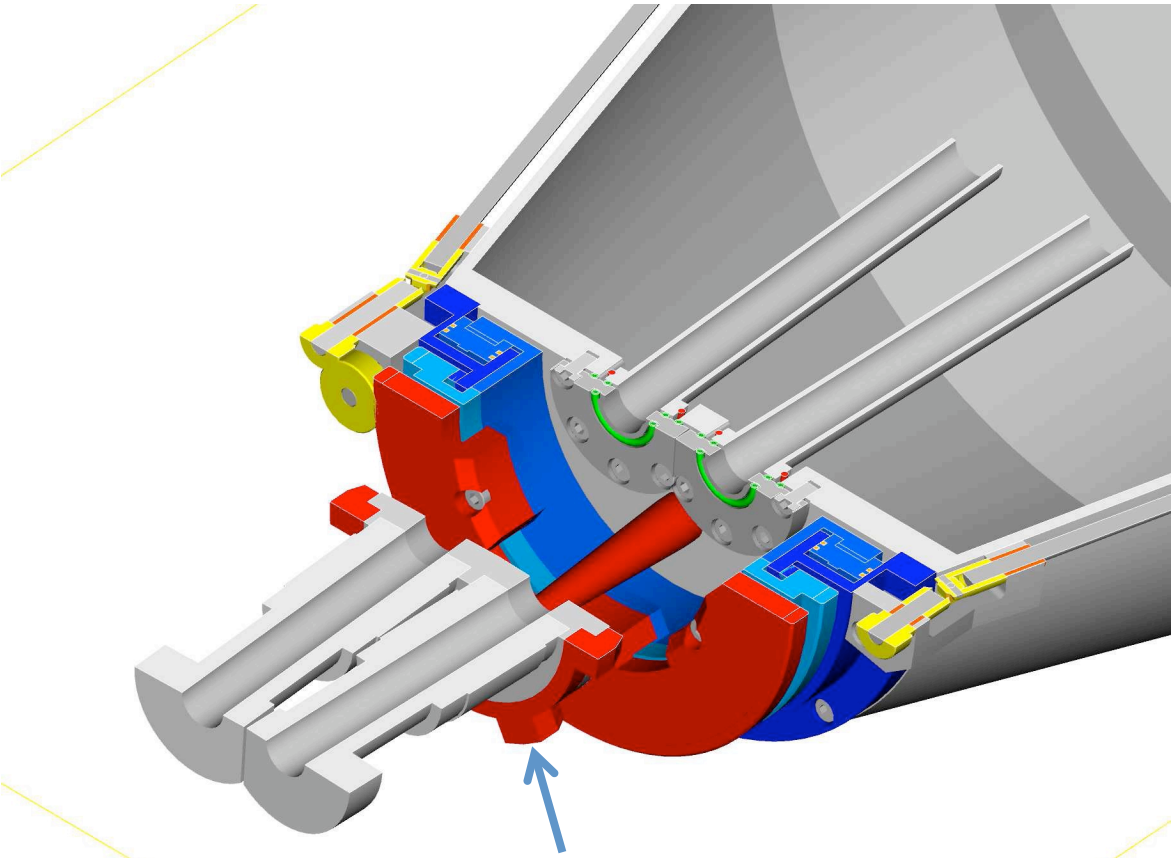
Little work space to access flanges.
It is impossible to connect flanges by hands in this configuration.

Issues toward Phase 2 and later

RVC: Bellows unit between IP chamber and QCS

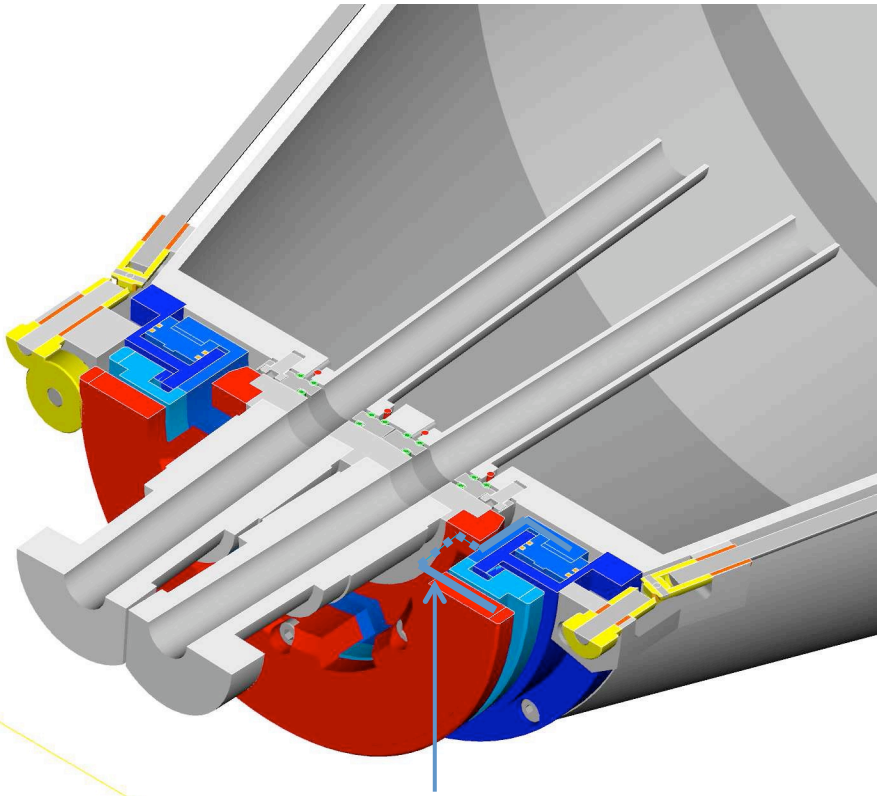


Picture 14 -19: How RVC works.



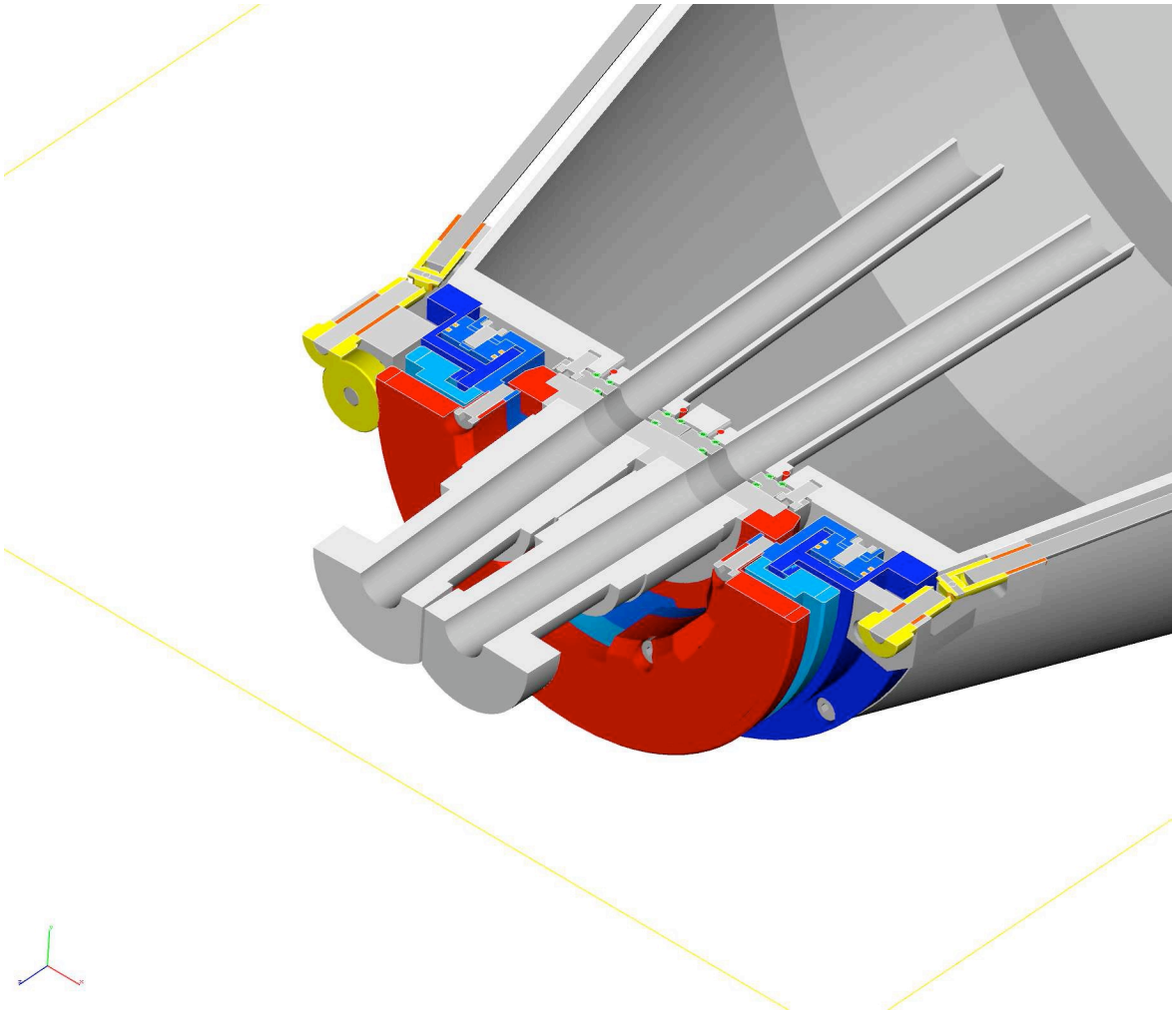
Two bellows units are attached to a single flange with a retainer.

Picture 15



These components rotate to catch the bellows flange.

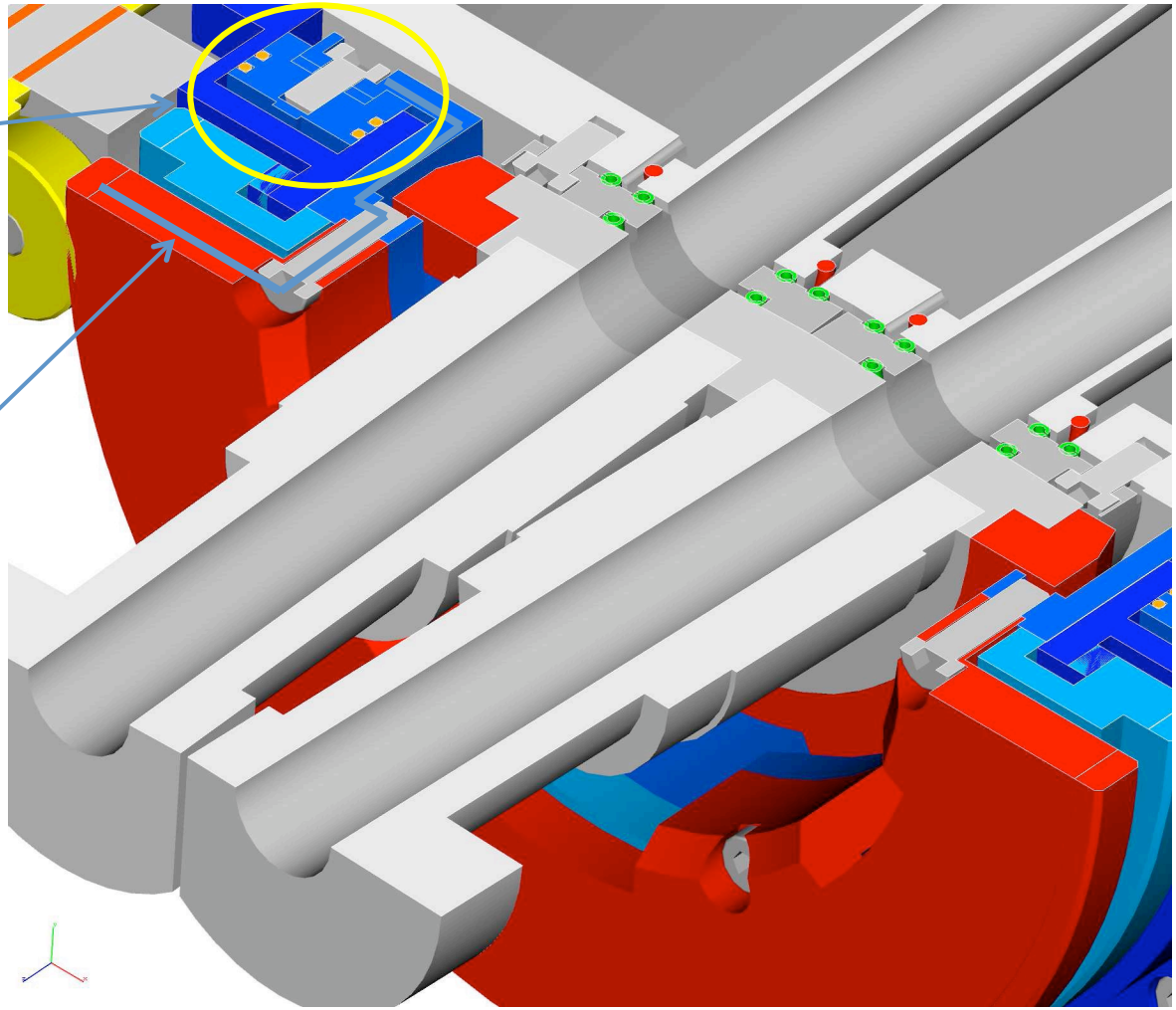
Picture 16



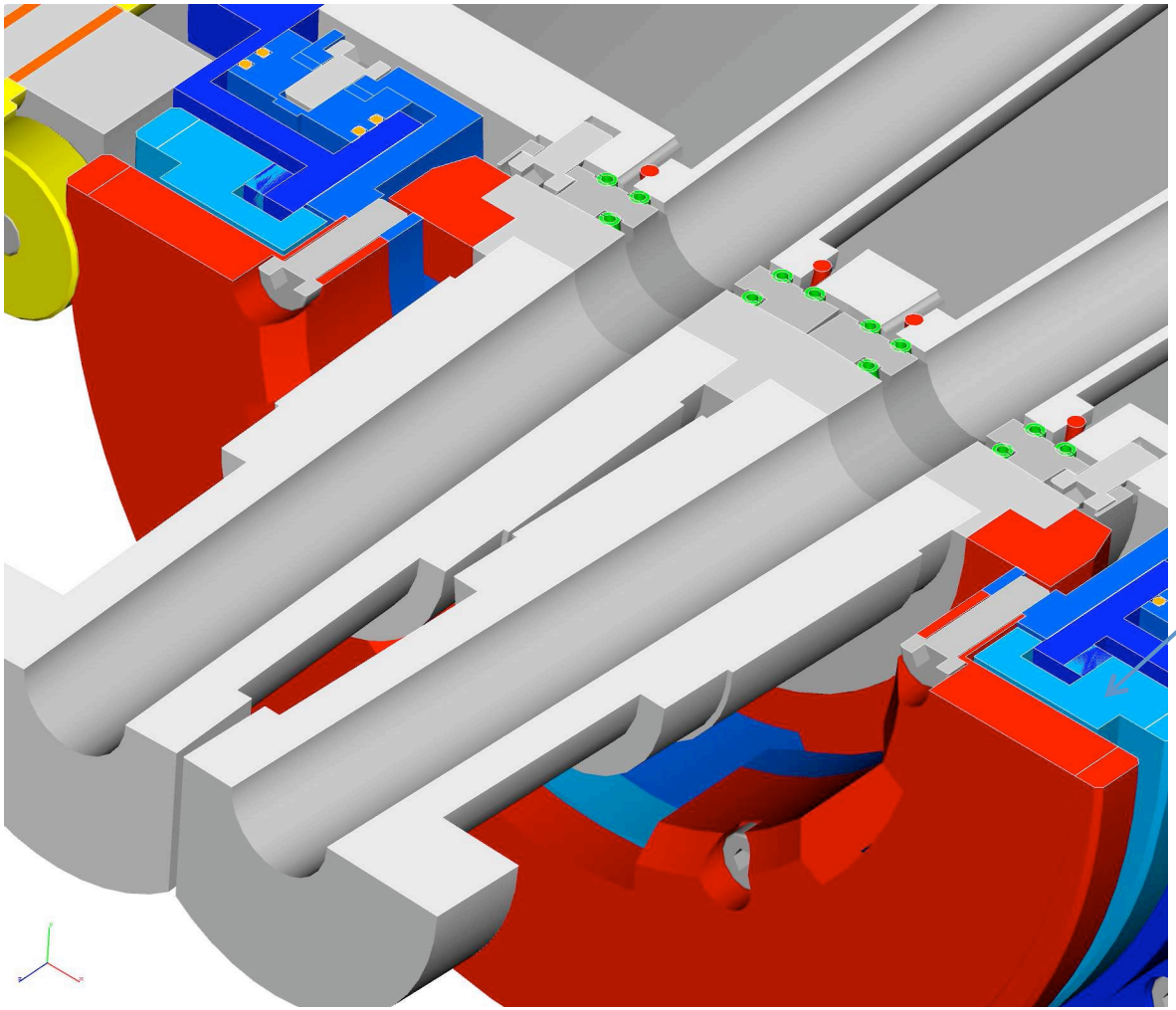
Picture 17

Cylinder for dry N_2 (about 50 bar)

These components shift to press the bellows flange to the cryostat.

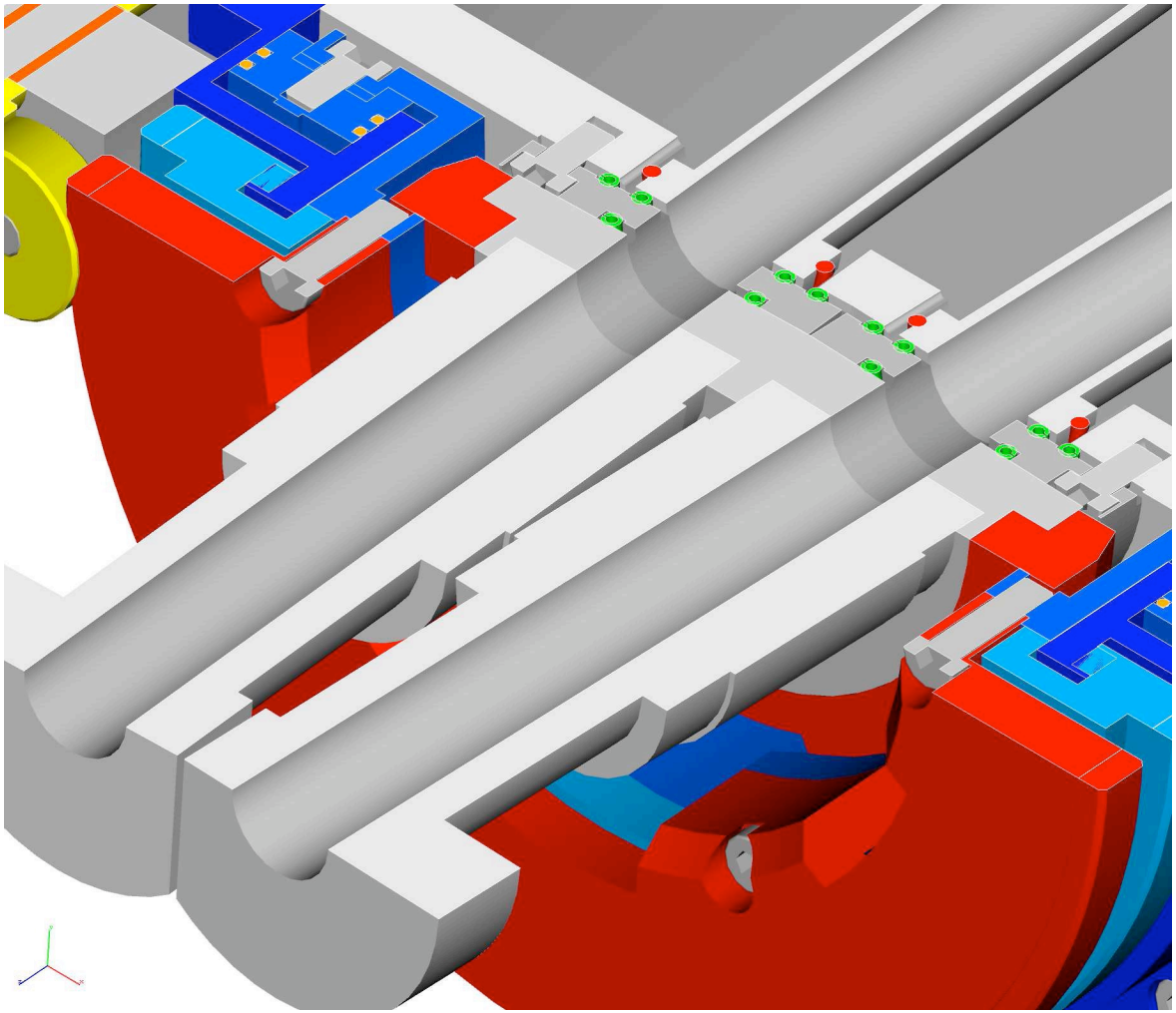


Picture 18



This large screw nut turns to lock the mechanism.

Picture 19



Issues toward Phase 2 and later

RVC: Approval

AIM with RVC was approved at 18th B2GM (18-21 June 2014).

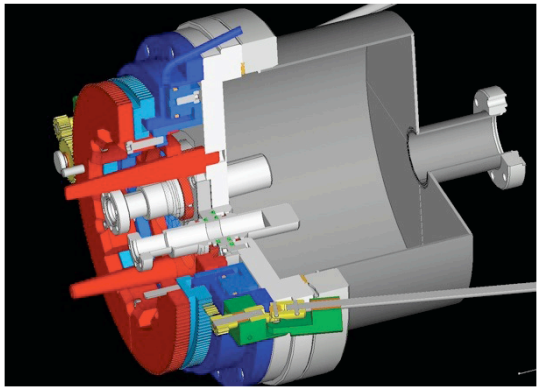
- The mock-up of RVC was transported from DESY to KEK.
- The vacuum tightness over several months (since November 2013) was verified. The demonstration included the opening and closing of the vacuum connection. After re-connection, the vacuum tightness was confirmed.

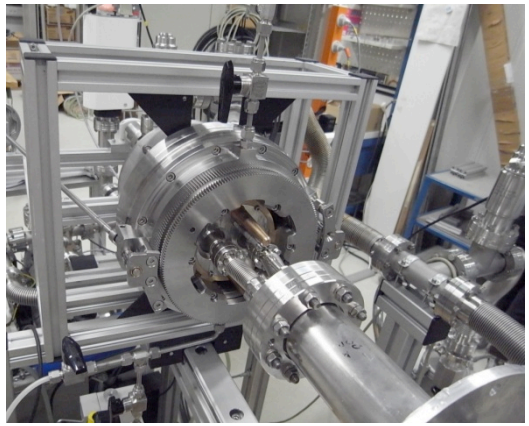
Emergency procedure when RVC is stuck was agreed.

- Left-hand side: Make a space for hand access by removing some electronics of CDC, and detach RVC from QCSL.
- Right-hand side: Pull out VXD with QCSR.

For the later deployment of the RVC, a Helium pipe for leak check after pipe connection and a guide tube for a fiber scope for visual inspection was requested by the vacuum group.

Comments from experiences on similar components are welcome.



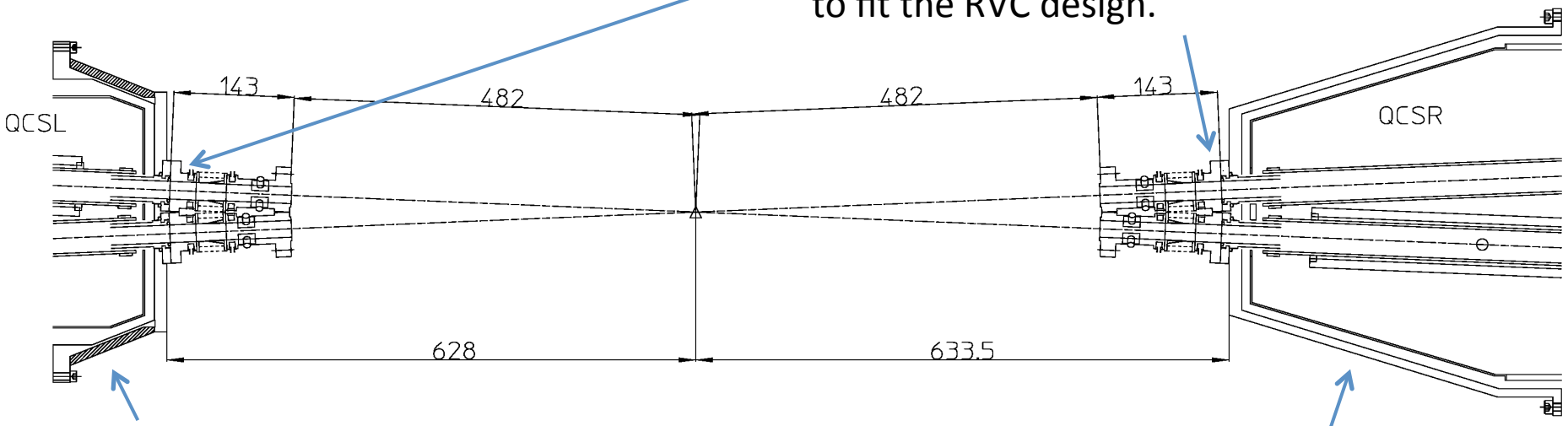


Issues toward Phase 2 and later

RVC: Boundary conditions (1)

- The distance of the front face of QCS is fixed.
- The basic shape of the front cap of QCS is fixed.
- The position of the sealing surface between a QCS beam pipe and a bellows unit is fixed.
- The length of the bellows unit is fixed.

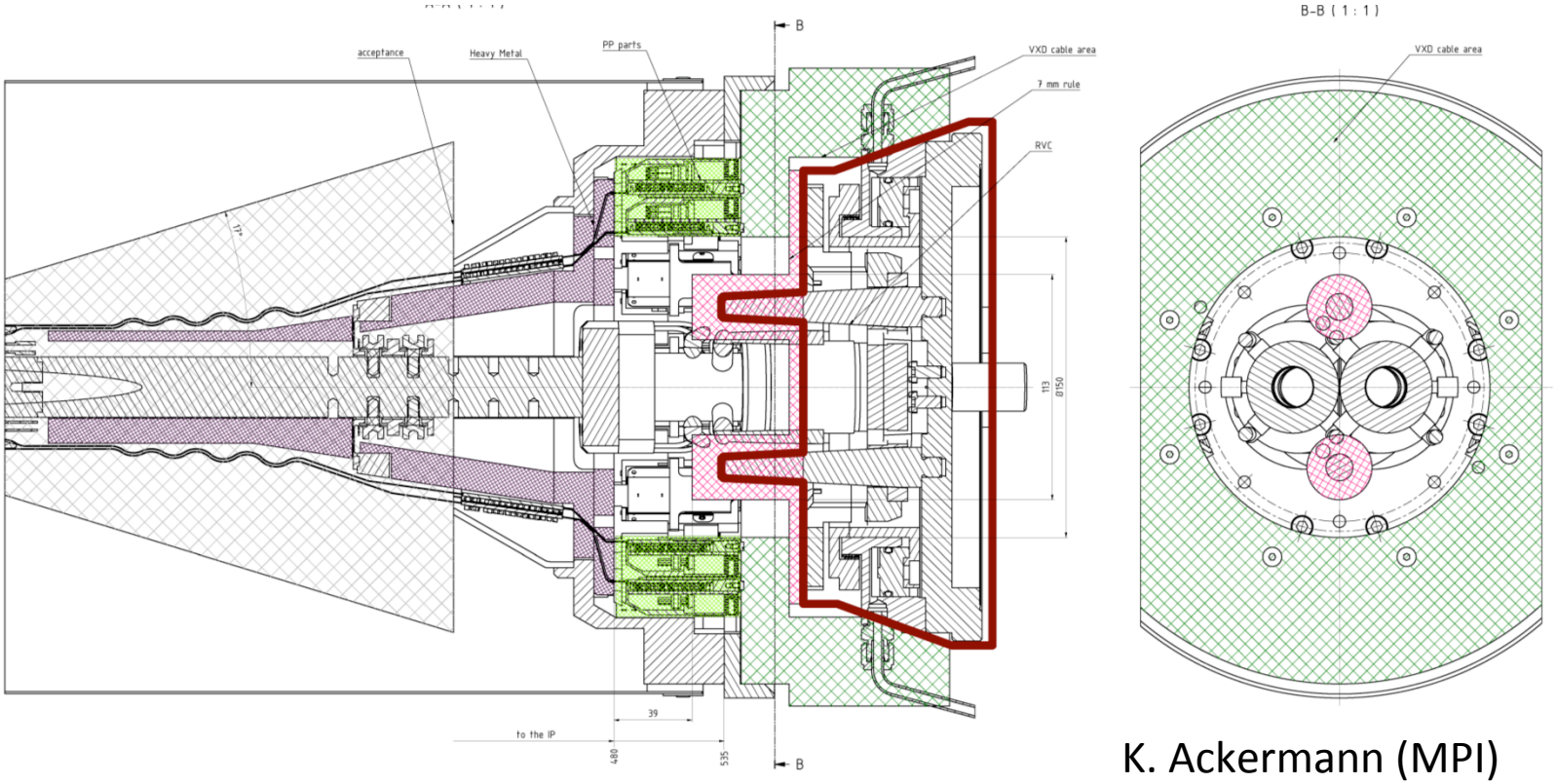
The QCS-side end of the bellows unit must be modified to fit the RVC design.



These front caps made of heavy metal and stainless steal replace the original caps when RVCs are installed. The design of their front face must be done along with the design of RVC.

Issues toward Phase 2 and later

RVC: Boundary conditions (2)



K. Ackermann (MPI)

The necessity of shields around the bellows unit next to IP chamber (Nakayama) is under discussion. Practically there is little space for the right hand side. The issue be discussed 8-9 May by Belle-II Members.

Issues toward Phase 2 and later

RVC: scheduling

2015 Now (KEK Vacuum group and Belle-II group)

- Boundary conditions related to the QCS cryostat is nearly fixed.
- Space allocation around the right-hand side RVC is still under discussion. This will be discussed 8-9 May by Belle-II Members.

2015 June – December (KEK and DESY)

- Design of RVC (DESY)
- Design of the bellows unit (KEK/DESY)
- Design of the front cap of QCS (KEK/DESY)

2016 (DESY and KEK)

- Fabrication and Laboratory test of RVC (DESY)
- Fabrication of the bellows unit (KEK/DESY)
- Fabrication of the front cap of QCS (KEK/DESY)

2017 March – April (before Phase 2)(KEK and DESY)

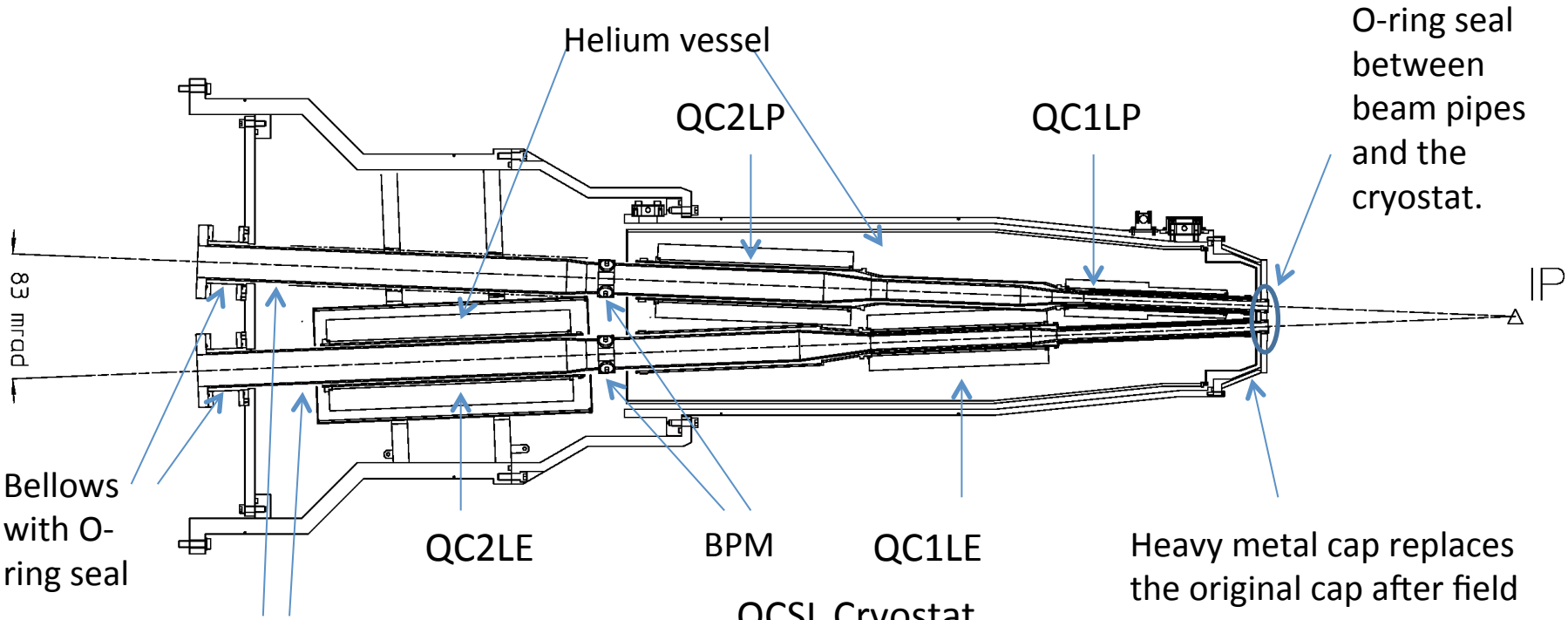
- Installation of RVC

Issues toward Phase 2 and later

Beam pipes for QCS

The first design was completed for the QCSL positron pipe. Material is changed from Ta (very expensive) to Stainless steel. Since QCS has a thick heavy metal (W) shield around beam pipes, this change has little effect on detector back ground.

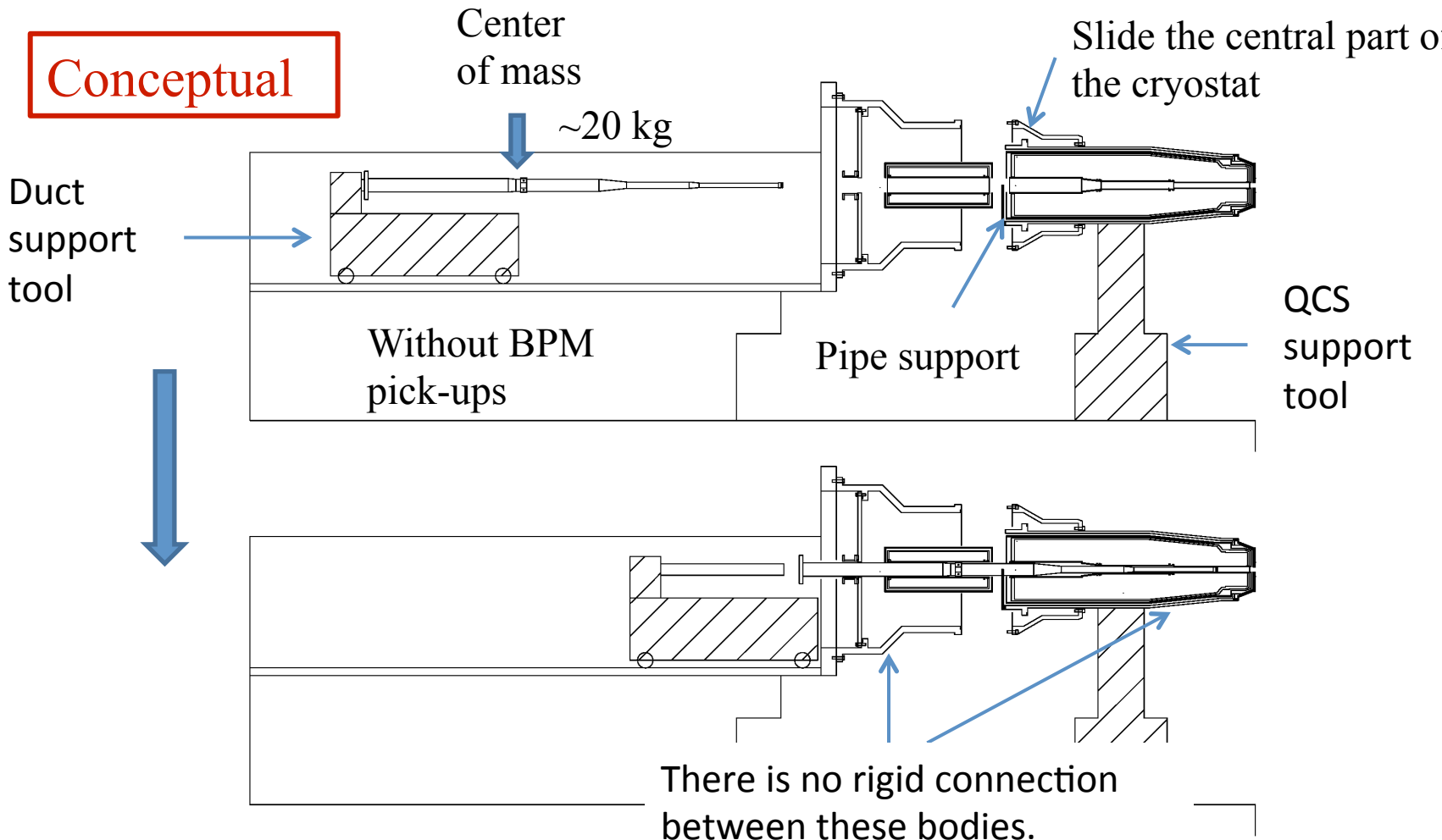
Four pipes will be prepared till March 2017.



Beam pipe with a 4 mm thick wall, and with water cooling channels therein

Issues toward Phase 2 and later

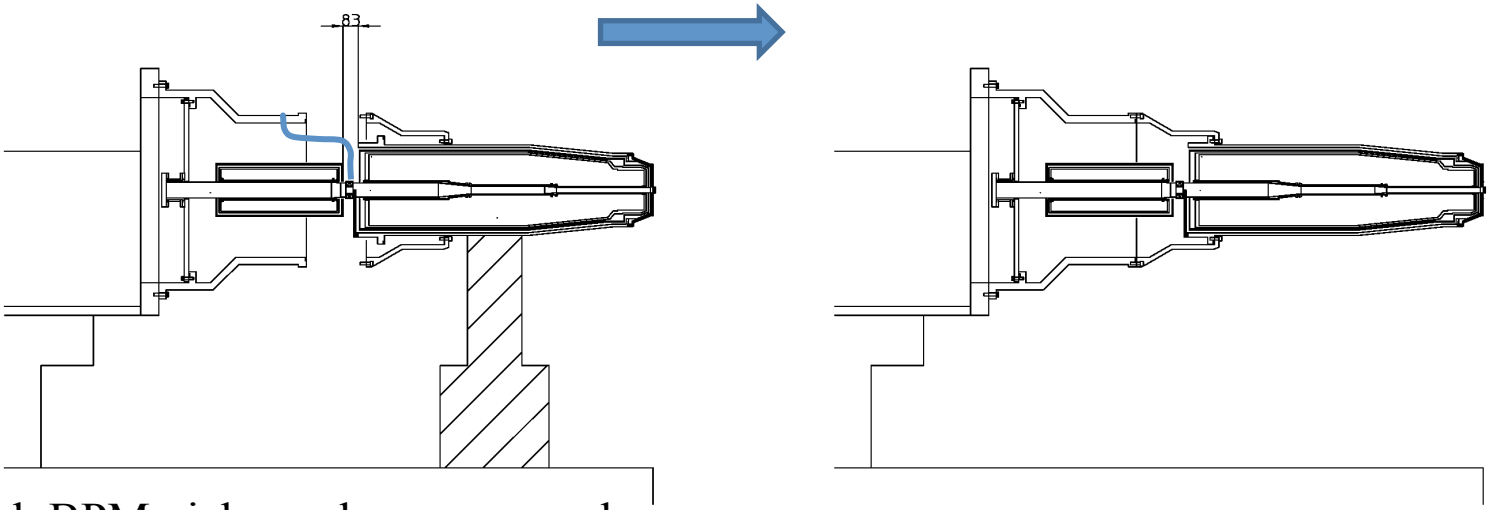
Beam pipes for QCS: Installation (1)



Based on the idea of N. Ohuchi

Issues toward Phase 2 and later

Beam pipes for QCS: Installation (2)



Attach BPM pick-ups by screws and connect cables.

Leak check!

This installation work seems very delicate. In preparing assist tools, necessary conditions must be discussed and be clarified.

Issues toward Phase 2 and later

Beam pipes for QCS: Installation schedule

FY2015

- Design of a duct support tool (Vacuum group)
- Design of a QCS support tool (QCS group)
- Fabrication of one or two beam pipes (Vacuum group)

FY2016

- Fabrication of a duct support tool (Vacuum group)
- Fabrication of a QCS support tool (QCS group)
- Fabrication of remaining beam pipes (Vacuum group)

2017 March -

- Installation:
    1. Remove pipes for field measurement from QCS
    2. Replace the front cap of QCS
    3. Install beam pipes
    4. Install RVC

Summary

- Preparation for Phase 1 is steadily in progress.
- The IP chamber for Phase 2 is completed. However, the next chamber for Phase 3 must be prepared without feedback from Phase 2 experiences. Any comments on the design are welcome.
- The use of RVC was approved at 18th B2GM (18-21 June 2014) after a well-performed demonstration. It is helpful to hear from experiences of the use of similar remote mechanism in inaccessible conditions.
- The first design was completed for the QCSL positron pipe. The cost of Ta beam pipe was found quite expensive. Material is changed to Stainless steel. Since QCS has a thick heavy metal (W) shield around beam pipes, this change has little effect on detector background.
- The installation of QCS beam pipes seems a very delicate work. More attention to the process and the preparation is necessary.