SuperKEKB mechanical assembly in the IR

-A report from a vacuum scientist-

The 2019 international workshop on the high energy Circular Electron-Positron Collider (CEPC)

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For all SuperKEKB IR fellows

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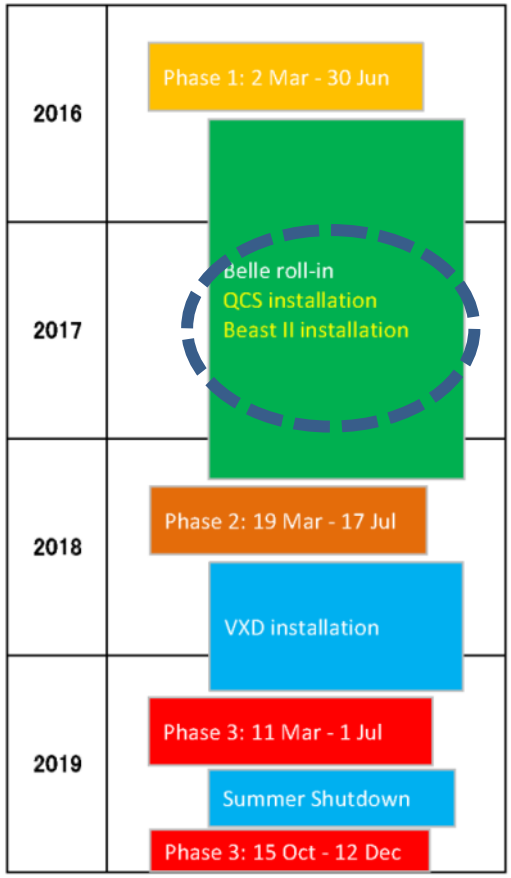
Very short introduction of SuperKEKB



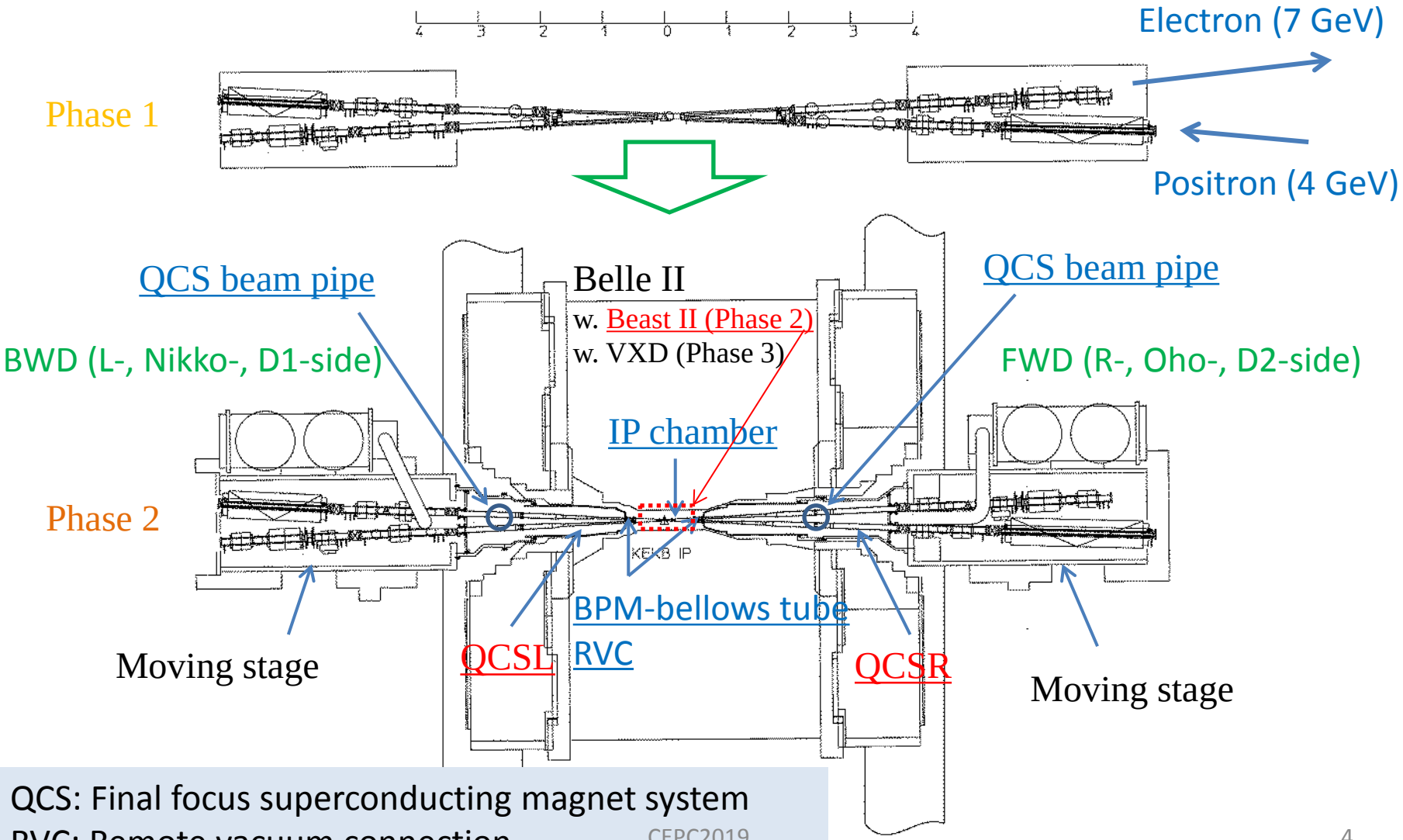
	SuperKEKB	CEPC	FCC-ee	
Circumference	3	100	100	km
Crossing angle at IP	83	33	30	mrad

This report is based on the work of this period

Commissioning history

- Phase 1 (from 2016, 2 Mar. to 30 Jun.)
  - No superconducting final focus magnets (QCS), No Belle II, No beam collision
- Phase 2 (2018, 19 Mar. to 17 Jul.)
  - With QCS, Belle II, and Beast II (for BG study), without vertex detector (VXD)
- Phase 3 (2019, 11 Mar ~)
  - With VXD (PXD incomplete)

IR from Phase 1 to Phase 2

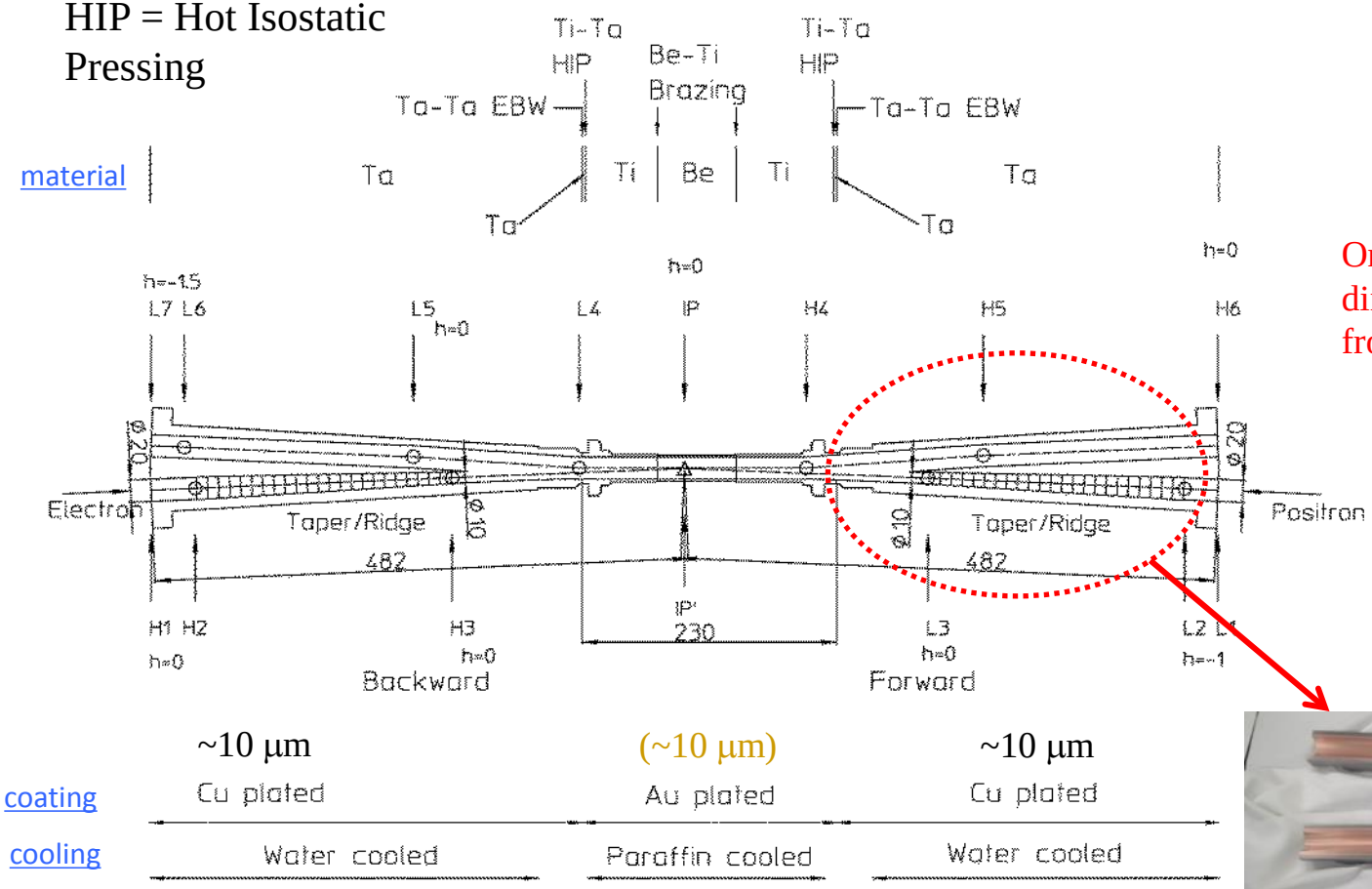


QCS: Final focus superconducting magnet system
RVC: Remote vacuum connection

BEAST II installation

IP chamber: Design feature

HIP = Hot Isostatic Pressing

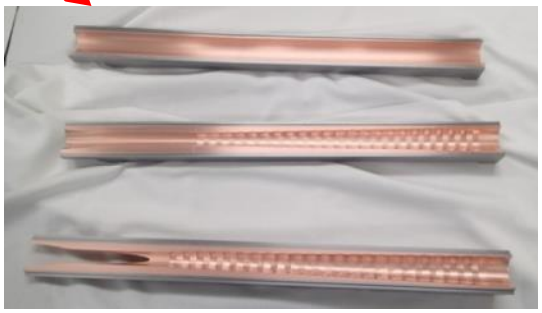


Beam space design with minimum trap of HOM at the central part.

ID of the beam passage ≤ QCS beam pipe (HOM propagates away.)
HOM is trapped at a merging volume of two passages.

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

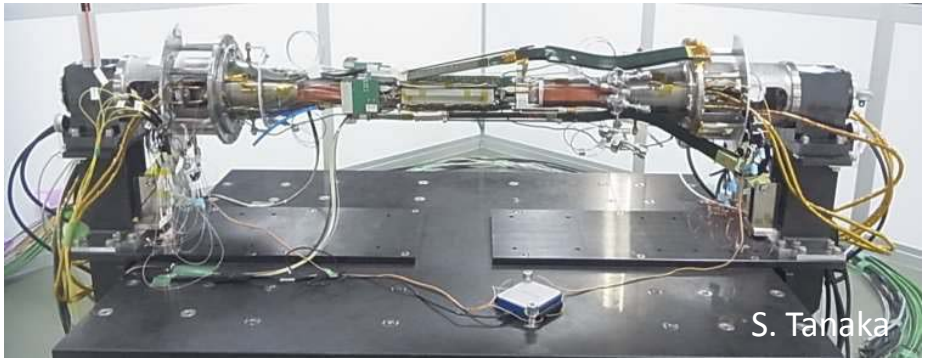


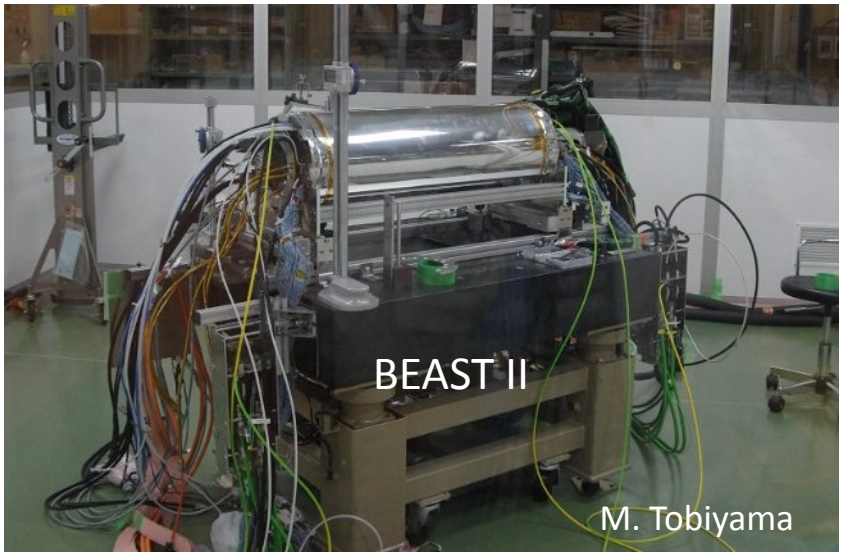
BEAST II installation

Assembling BEAST II around IP chamber

•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

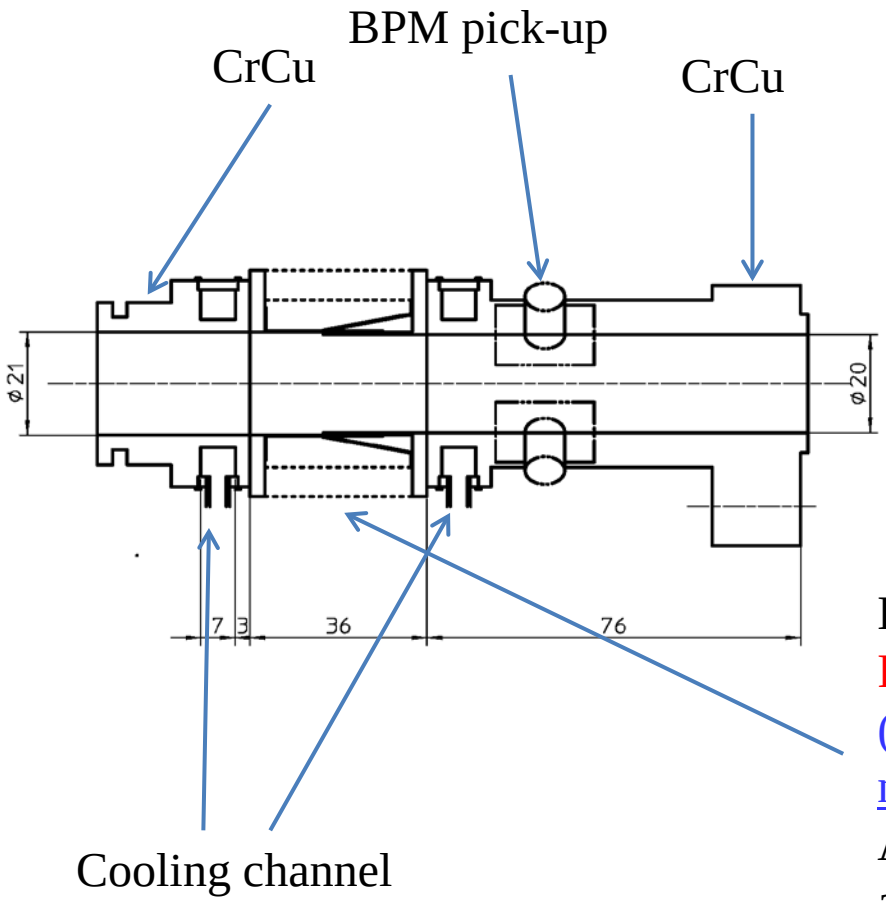


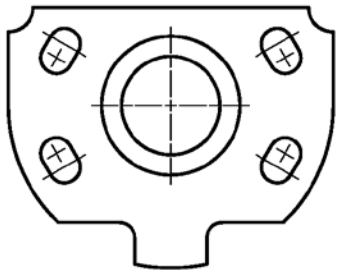


BEAST II installation

BPM-bellows tube between IP chamber and QCS

QCS side





Bellows unit with a conventional RF-bridge.

(At present, no problem up to 800 mA)

A comb-type structure cannot give a sufficient flexibility for a small diameter.

Connecting BPM-bellows tube

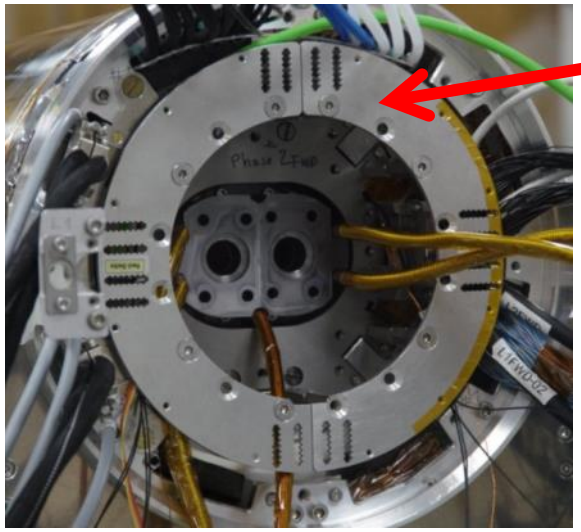
Beast II assembling group strongly suggested that it is practically impossible to connect BPM-bellows tubes to the IP chamber after BEAST II is installed into Belle (especially in FWD).
Therefore, The tubes were connected to the IP chamber before BEAST II installation.

Travel limiter to limit the longitudinal displacement of the bellows.

Lock flange

BPM-bellows tubes (about 14 cm long) set on a lock flange for RVC

Connecting BPM-bellows tube



Cable cage

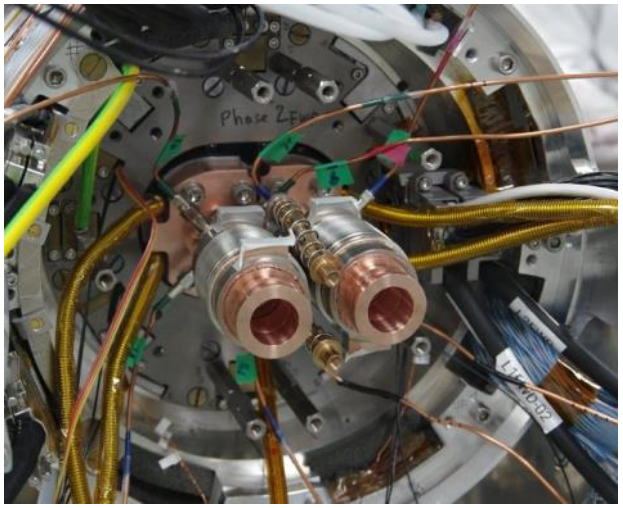
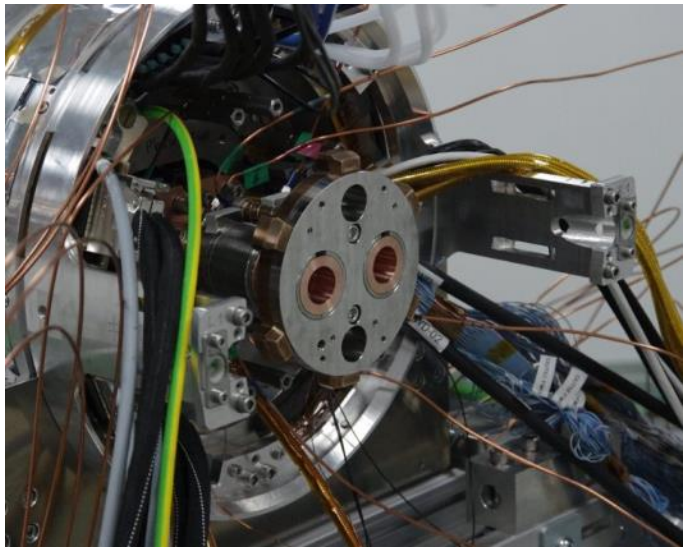


Photo by
M. Tobiyama



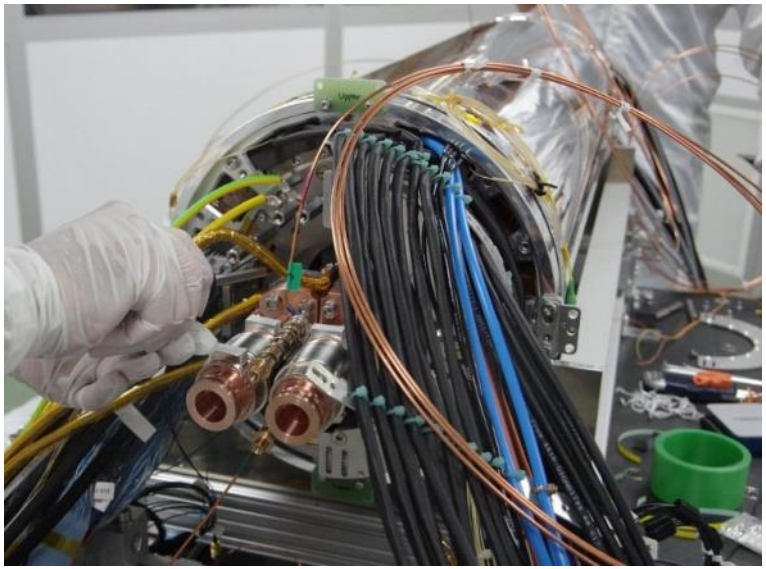
FWD

The vacuum flanges of IP chamber is about 8 cm behind the cable cage.

The cable cage interfered with connecting work. It is temporally removed.

Connecting BPM-bellows tube

Photo by M. Tobiyama



BWD
The vacuum flanges of IP chamber is outside of the cable cage.

Vacuum leak check

Beast II installation (Nov. 18, 2017)

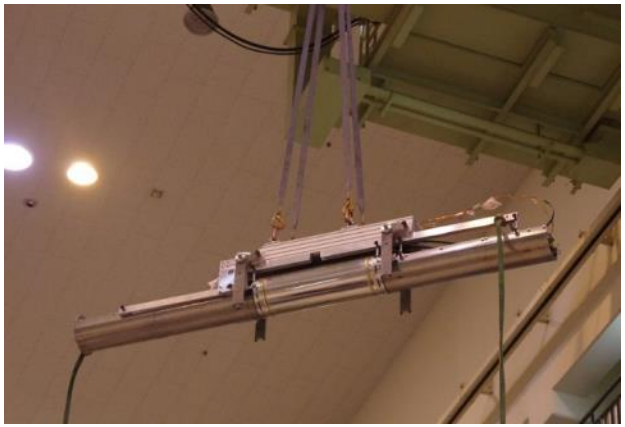
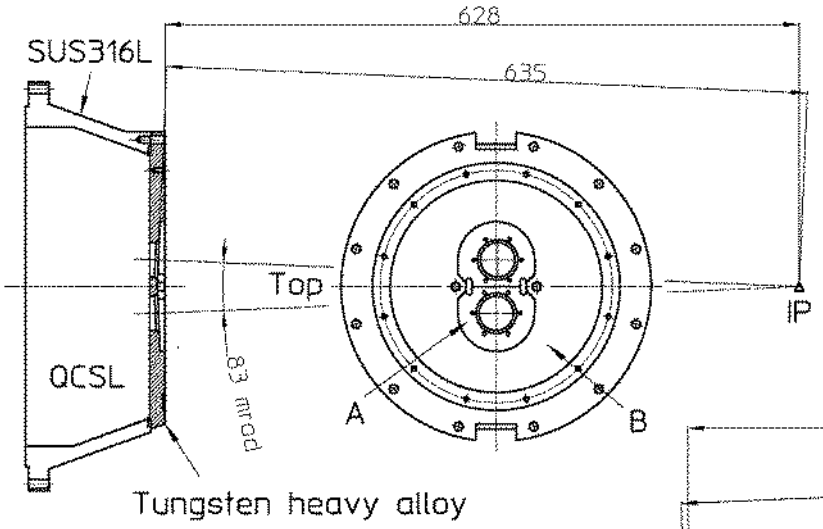


Photo by M. Tobiyama

Review of work

- It was necessary to connect semi-rigid BPM cables to BPM-bellows tube before connecting the tube, because of limited work space. BEAST II structure strongly restrict the work space.
- Since a bellows is a fragile component, we need to establish a method how to replace it, even for such bellows set deep inside the detector.
  First idea was to extract VXD from Belle II. But Belle II people resisted this idea, and RVC was introduced.
  Present situation is:
  BPM-bellows tubes at BWD can be replaced while leaving VXD inside.
  On the other hand, at FWD, it is necessary to extract VXD to exchange them.

New cryostat head



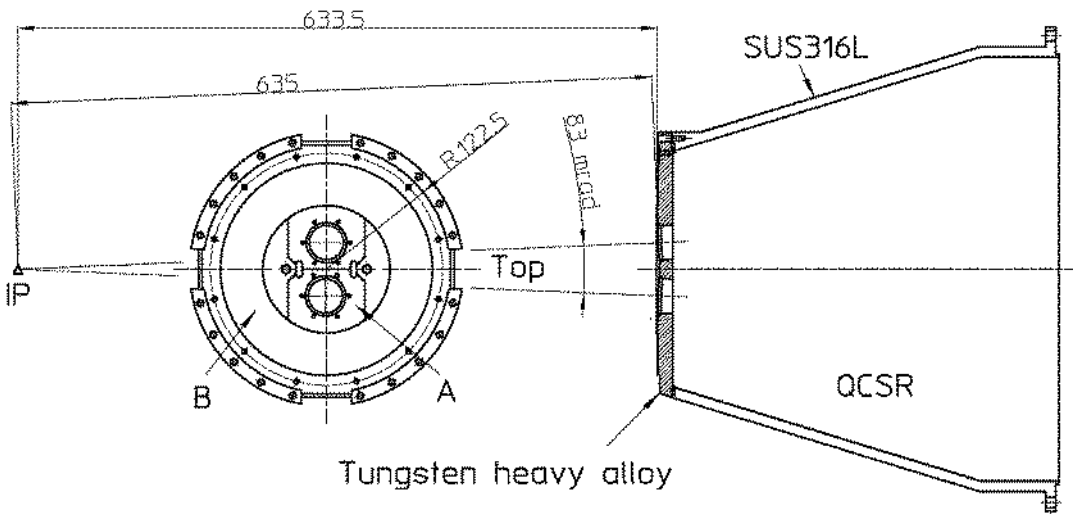
QCSL cap

A new front head which has a W-alloy face was prepared for each cryostat. The face is machined to install RVC on it.

RVC: Remote Vacuum Connection (picture later)

Exchange the cryostat head

Leak check of the cryostat

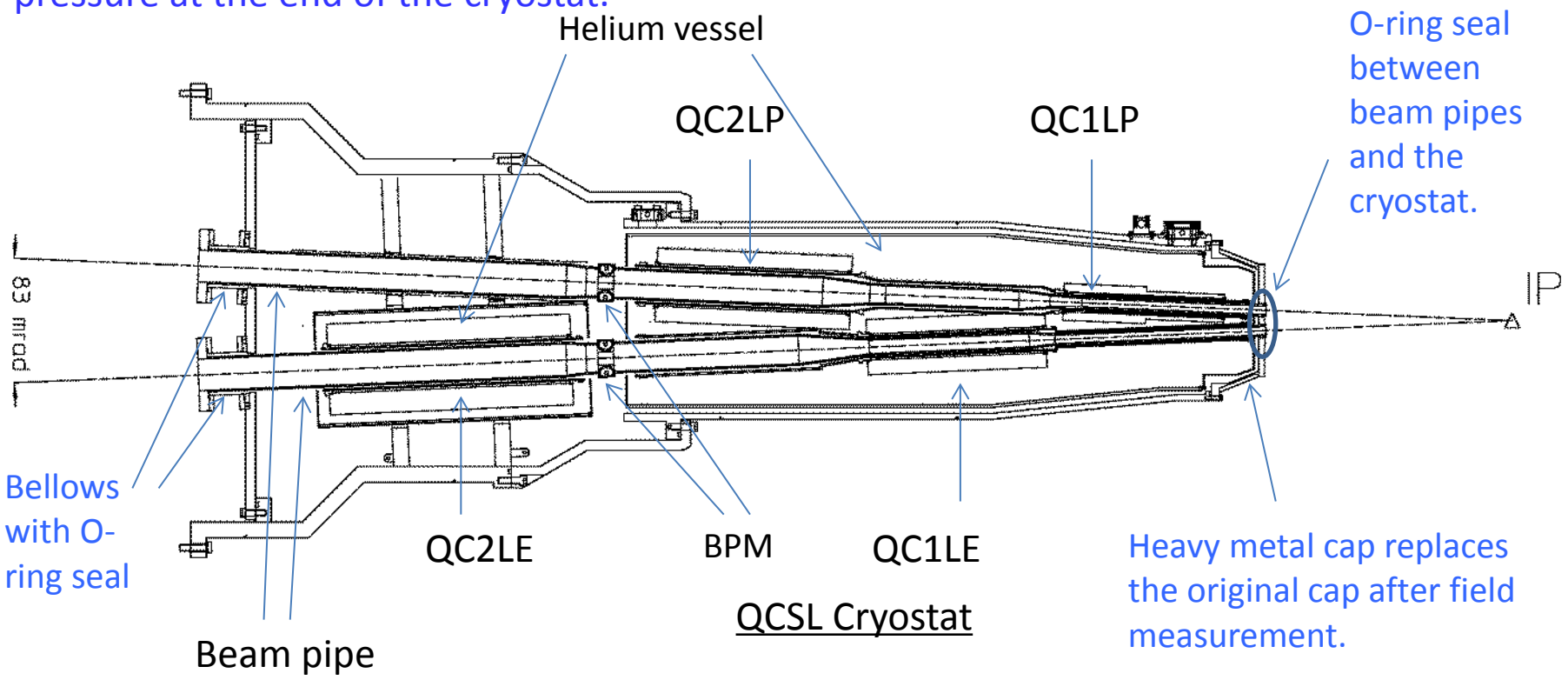


QCSR cap

Fig2

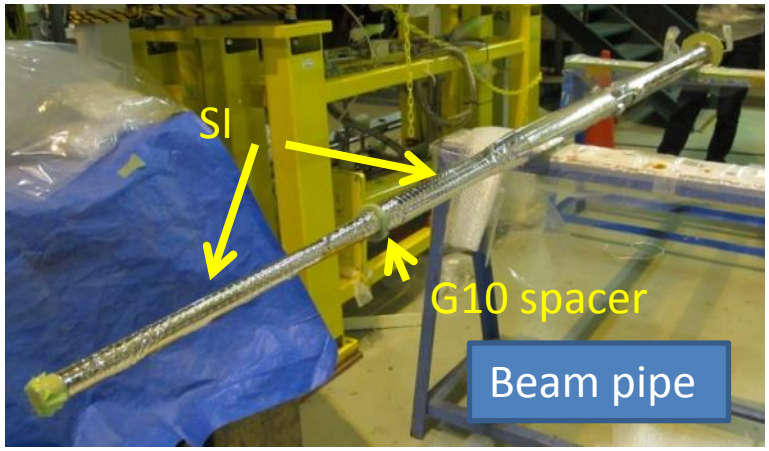
Beam pipes for QCS

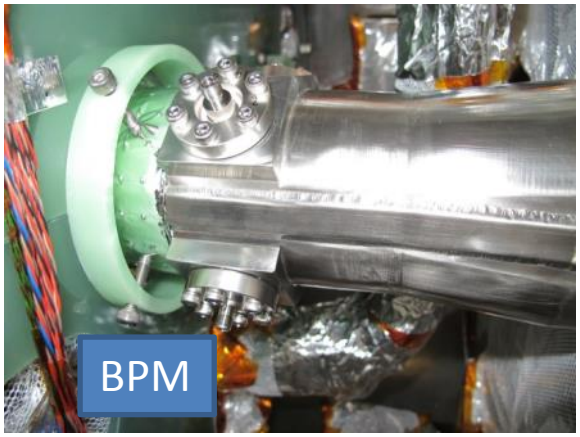
After field measurement, inner pipes of the cryostat were replaced with beam pipes. The beam pipe is made of stainless steel, with a 4 mm thick wall, and with water cooling channels on both sides. Inside surface is Cu (+TiN) coated. It is fixed to the QCS cryostat. The beam pipe has no pump. Pressure at the IP is about one order higher than the pressure at the end of the cryostat.



QCS beam pipe installation

Photo by Y. Arimoto





Set beam pipe

↓

Attach BPM and leak check

↓

Connect BPM cable

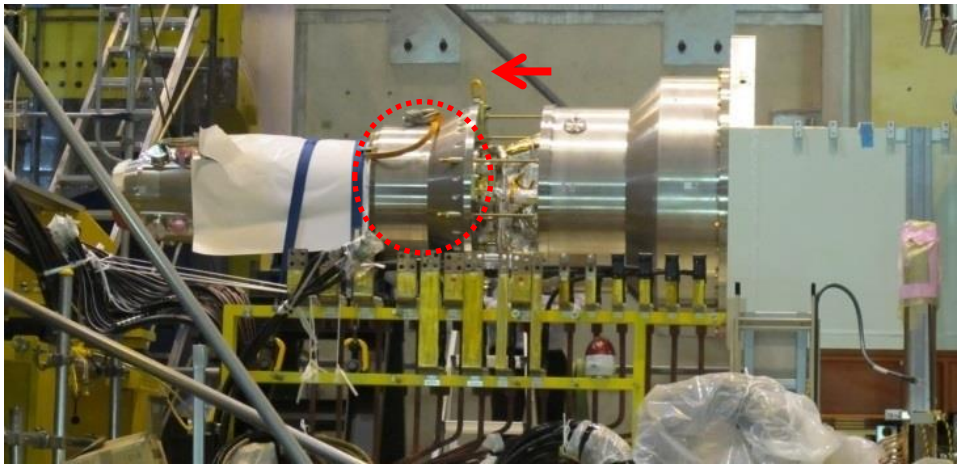
↓

Leak check of the cryostat

Beam pipe is inserted using a special tool

Service window on the QCSR cryostat used to manually guide the beam pipe and to attach BPM

QCS beam pipe installation



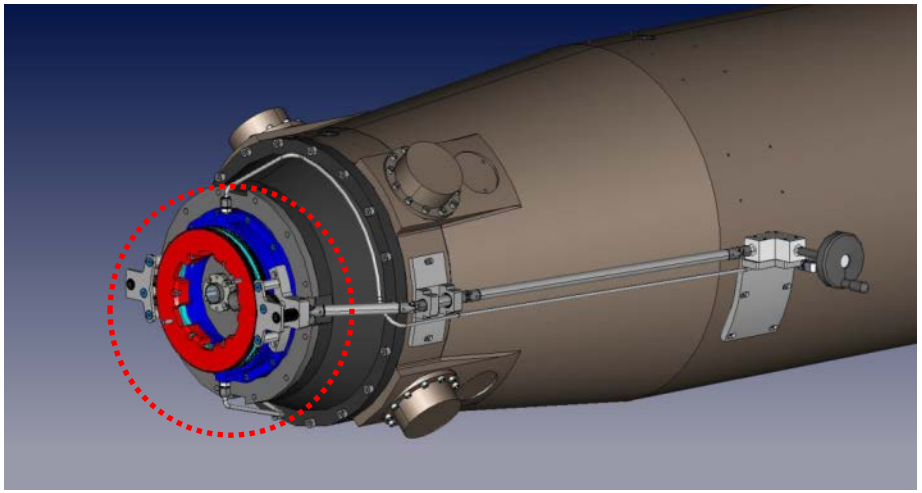
Since QCSL has no service windows, the cryostat was disassembled for this work.

Photo by Y. Arimoto

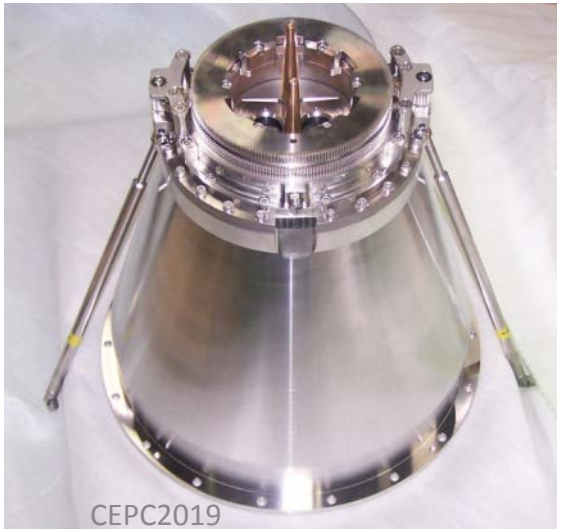
Review of work

- The QCSL cryostat was disassembled to install beam pipes.
  - Magnet group checked marker positions on the cryostat after re-assembling. Roughly speaking, the front body is rotated anti-clockwise by 0.7 mrad seen from IP. The consistency of the measurement with the mechanical tolerance of the cryostat design is not yet given.
- It seems better to separate a cryostat and beam pipes mechanically.
  - A cryostat position can be adjustable after beam pipes are connected.
  - Beam pipes can be heated up if necessary (ex. NEG coating).
  - Then, the design of RVC will be different.

Remote Vacuum Connection (RVC)



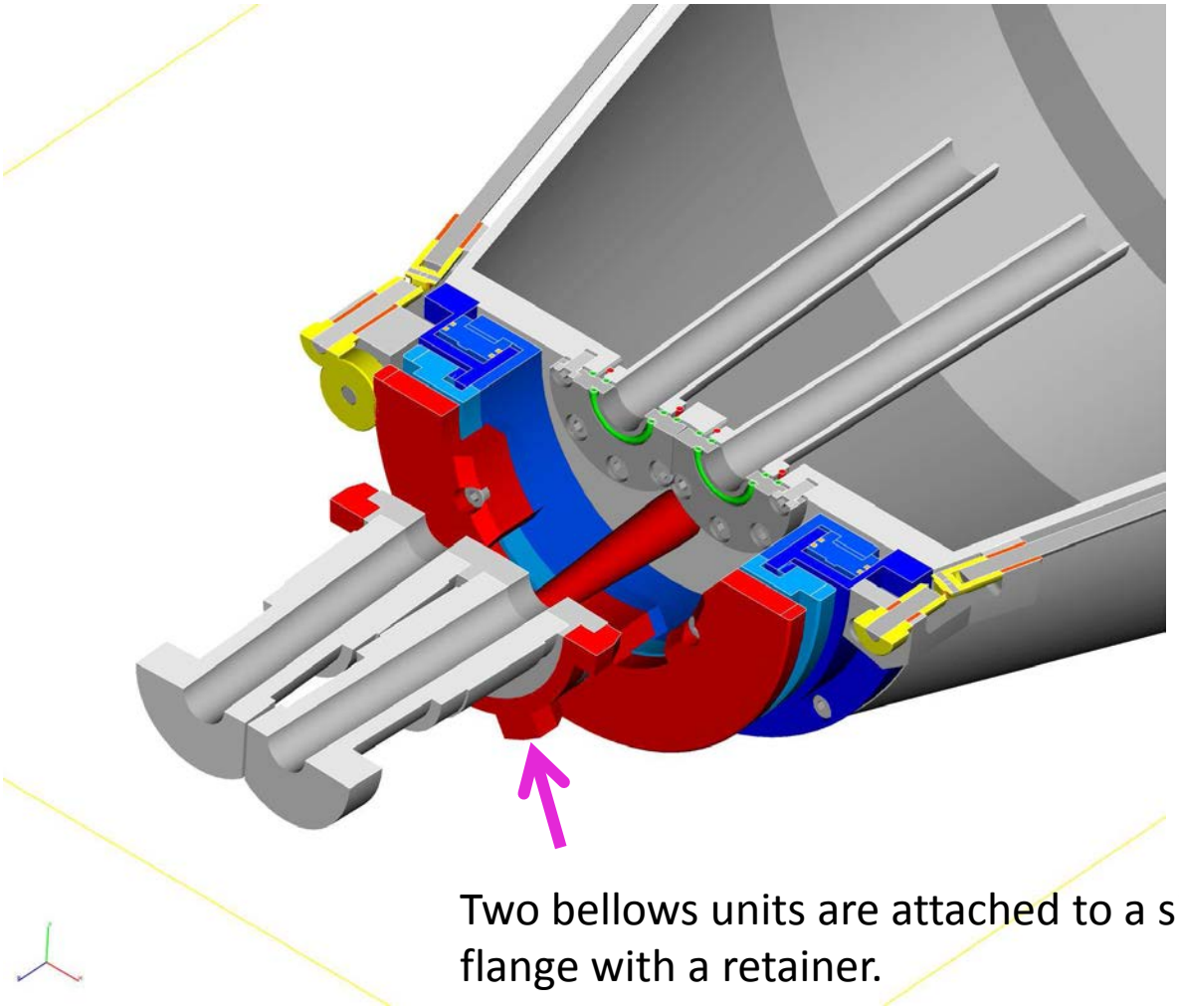
RVC is a mechanism introduced by Belle group to connect QCS beam pipes to BPM-bellows tubes by a remote manipulation.
RVC was designed and produced by DESY.



RVC on the new QCS head

Photo by DESY

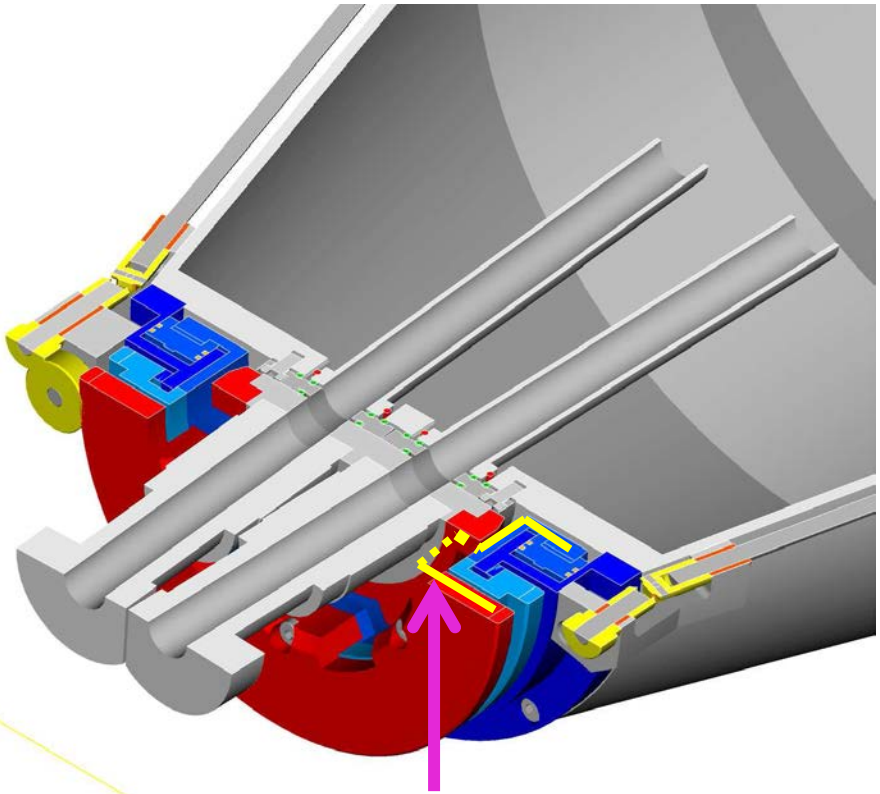
How RVC works 1/6



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

Drawing by Karsten G.

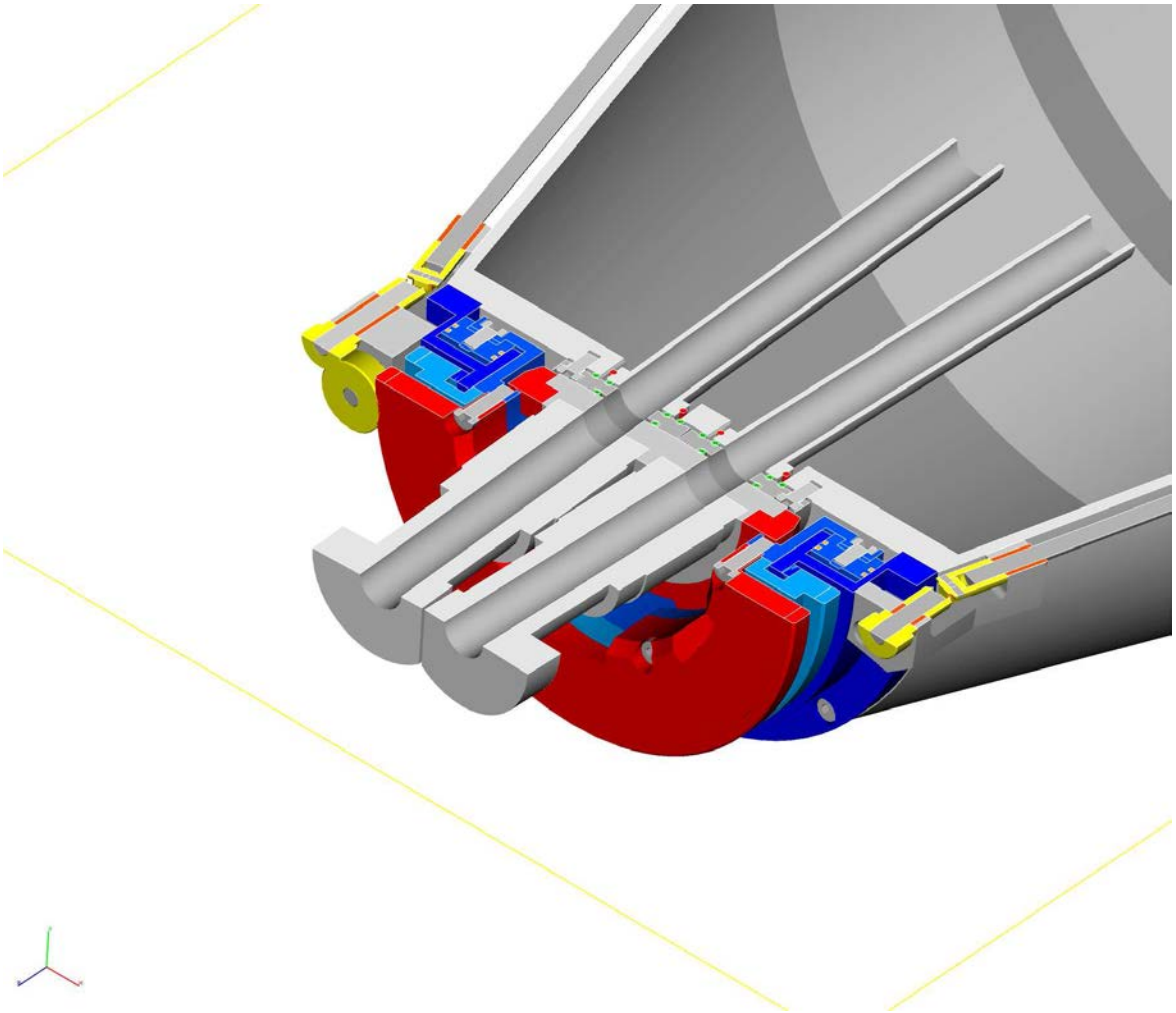
How RVC works 2/6



These components (red+blue) rotate to catch the lock flange.

Drawing by Karsten G.

How RVC works 3/6

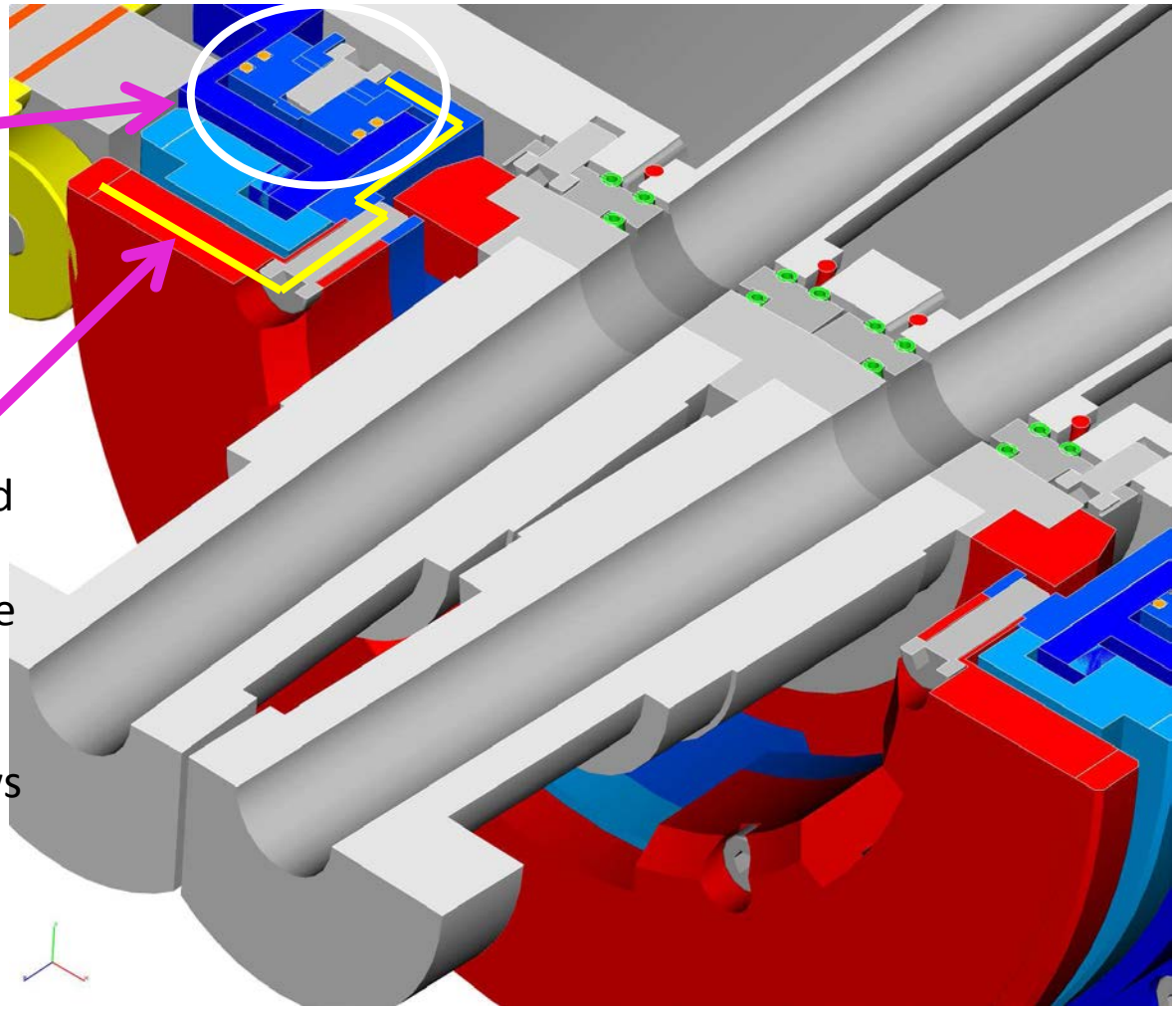


Drawing by Karsten G.

How RVC works 4/6

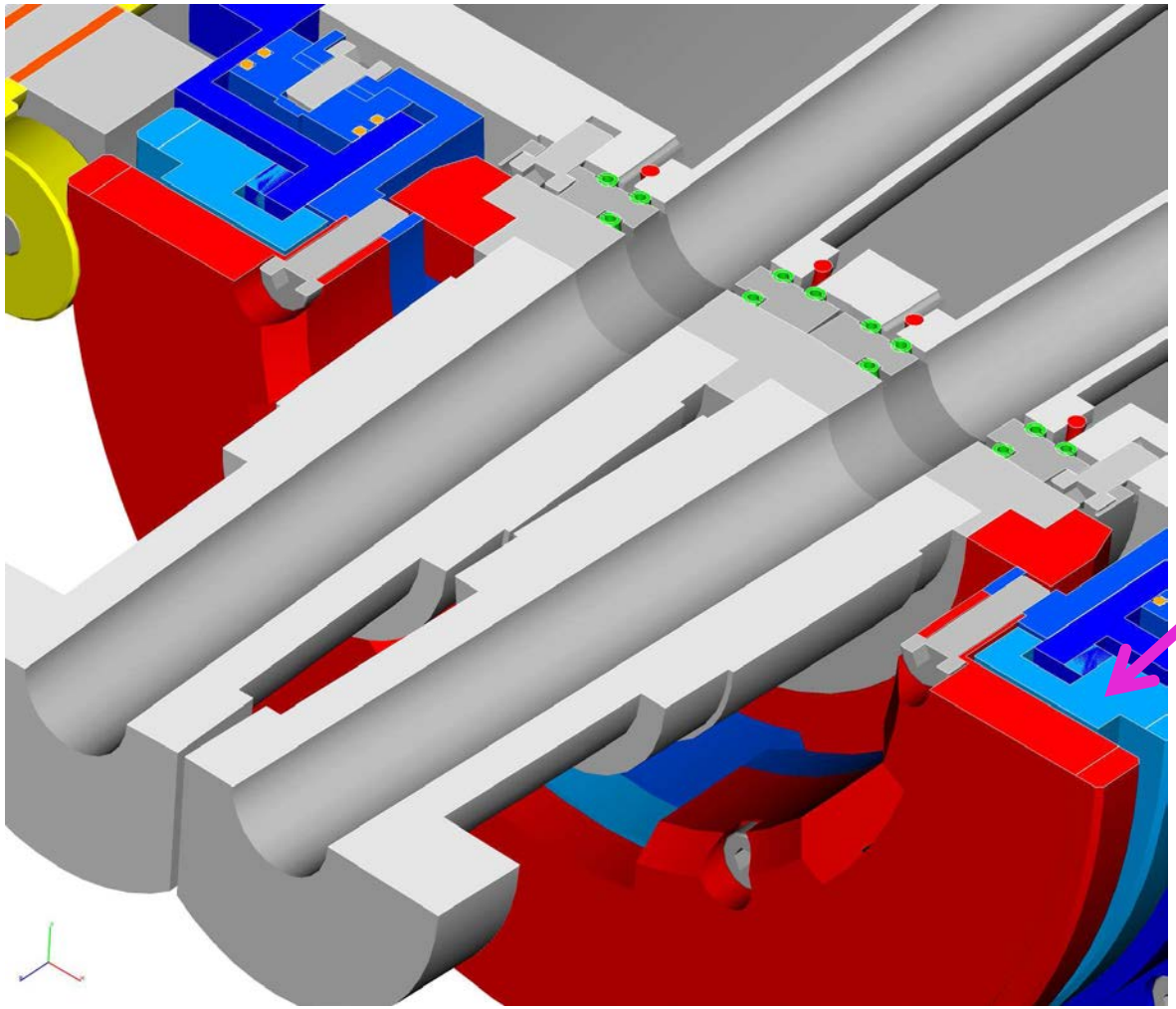
Cylinder for dry N_2 (about 50 bar)

These connected components connected to the piston in the cylinder, shift to press the bellows flange to the cryostat.



Drawing by Karsten G.

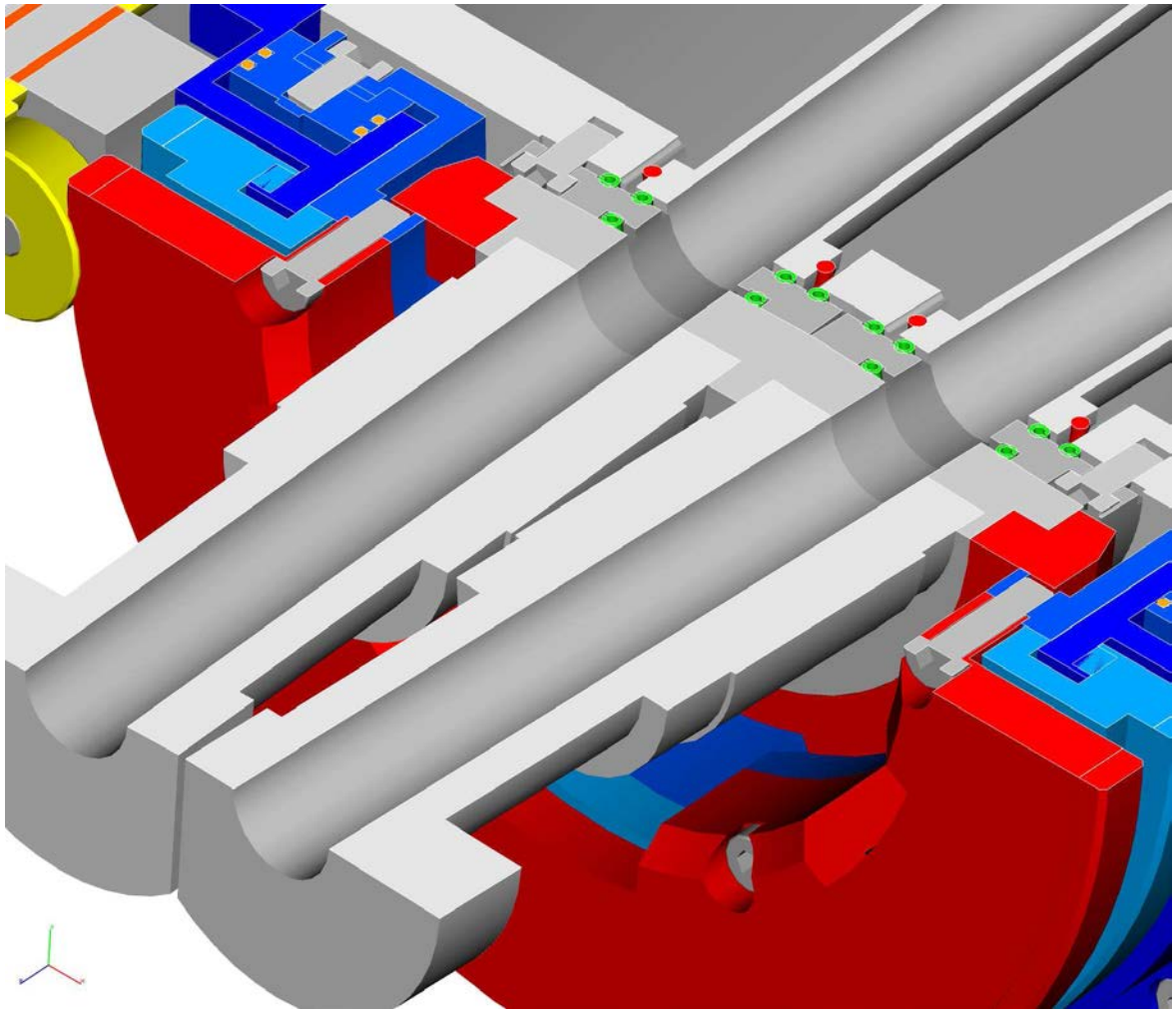
How RVC works 5/6



This large light blue screw nut turns to lock the mechanism.

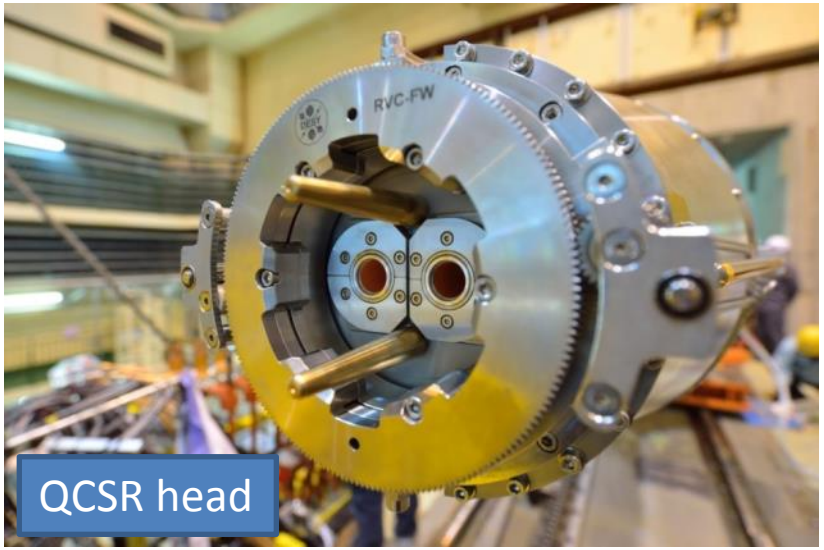
Drawing by Karsten G.

How RVC works 6/6

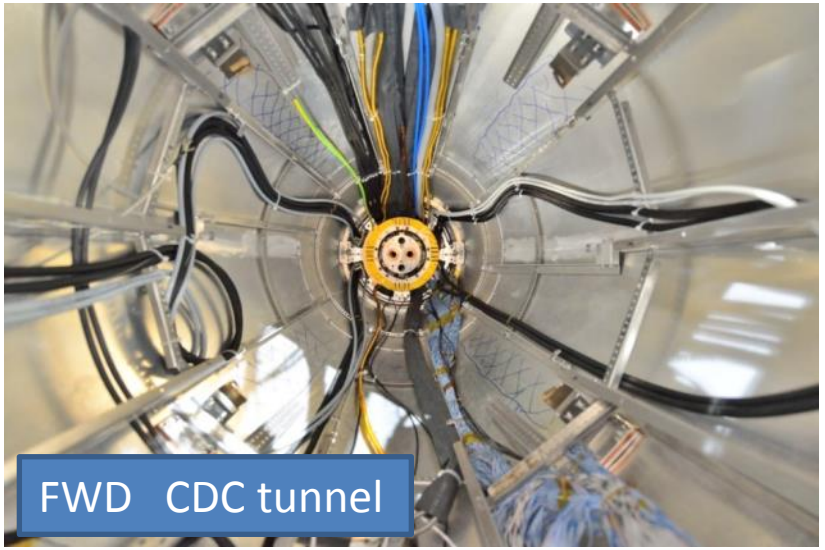


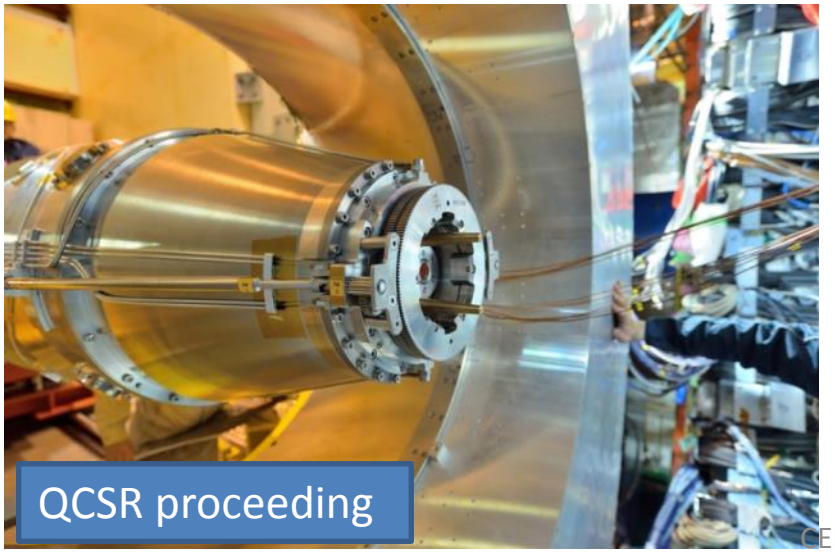
Drawing by Karsten G.

QCSR-Beast II connection (Jan. 9, 2018)



QCSR head


FWD CDC tunnel


QCSR proceeding

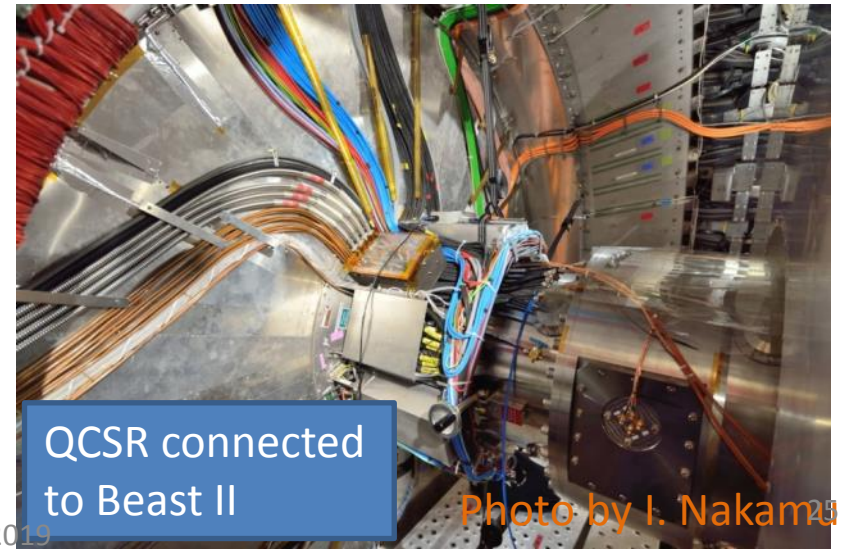
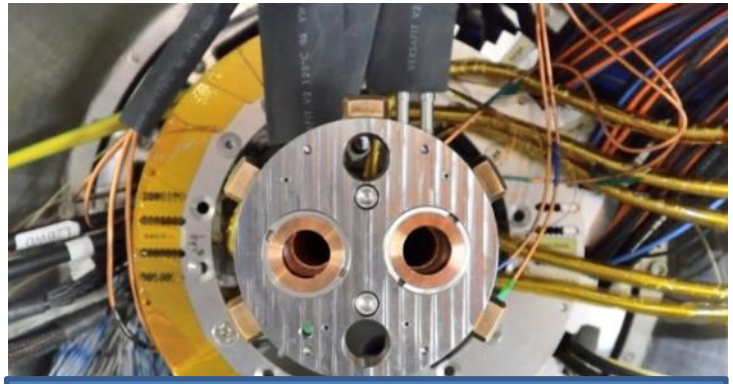

QCSR connected to Beast II

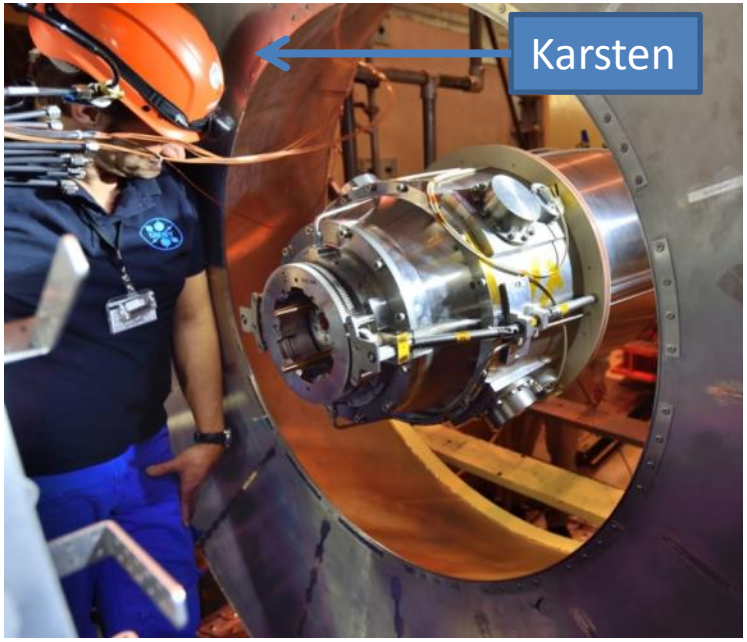
Photo by I. Nakamura

QCSL-Beast II connection (Jan. 15, 2018)

Trouble!! A number of contact fingers are out of place.



Contact fingers were miraculously put in order by Karsten (DESY)



Leak checking scene

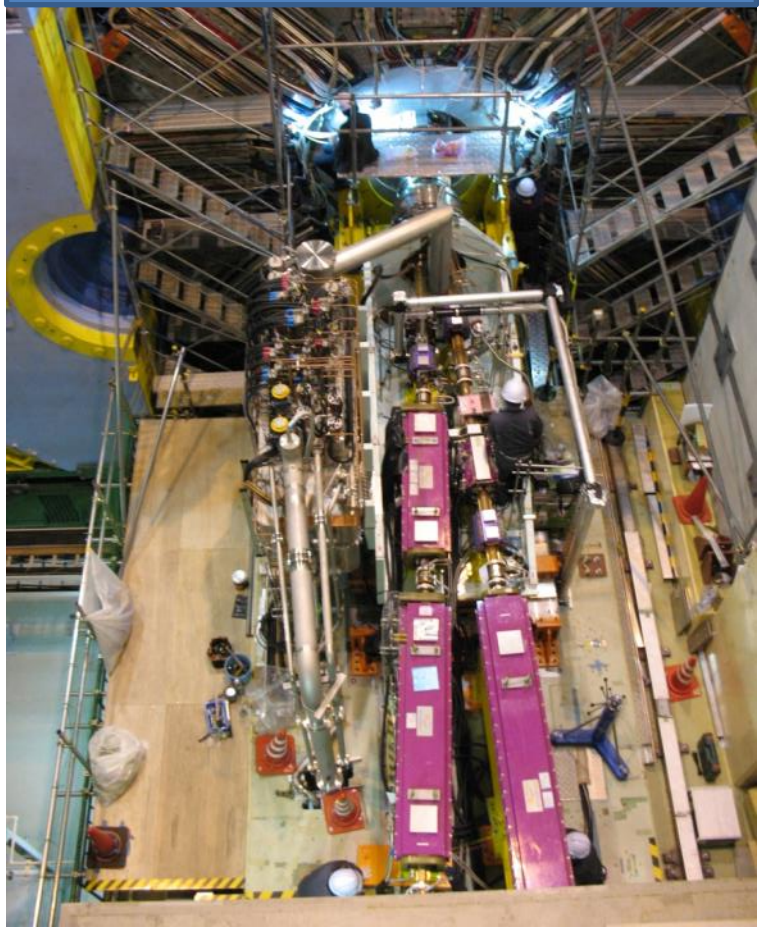
Photo by I. Nakamura

Review of work

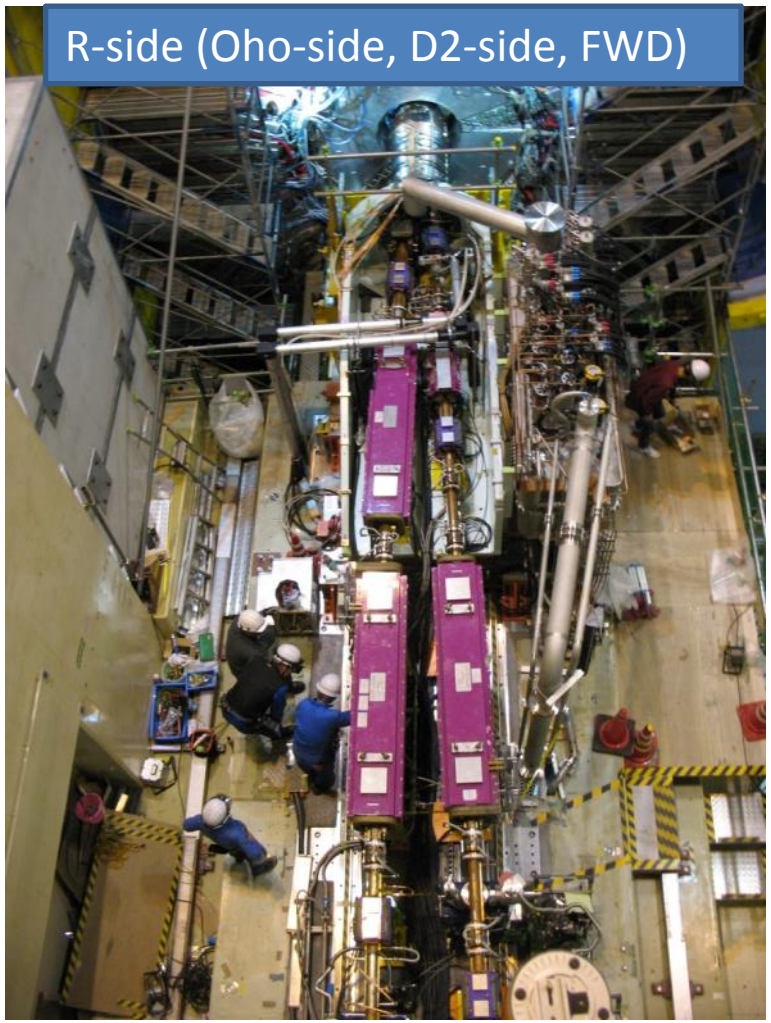
- Just before QCSL-Beast II connection, it was found that contact fingers of one BPM-bellows tube were out of place. This seems to be caused by an accidental large turning of the lock flange. Happily enough, this was repaired by Karsten.
  - However, after Phase 2 operation, discoloring due to discharge was observed around these fingers. The deformed fingers did not fully recover their shape as fabricated.
- RVC worked completely well.

IR after QCS-BEAST II connection

L-side（Nikko-side, D1-side, BWD）



R-side (Oho-side, D2-side, FWD)



All magnets are re-installed, all beam pipes are connected. Cabling and other works are going on.

Finally concrete radiation shields cover accelerator components

END