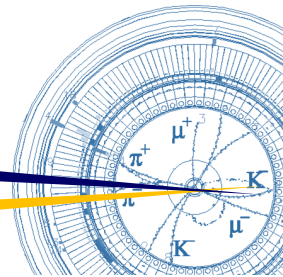


# Vacuum system of SuperKEKB interaction region



Kyo Shibata

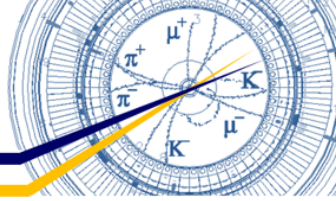
(on behalf of SuperKEK Vacuum Group)

2021.10.27

TRIUMF 2021 EIC Accelerator Partnership Workshop

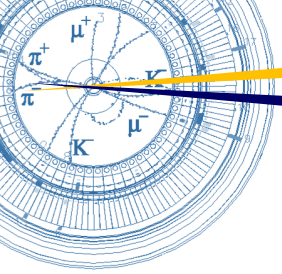
ESR vacuum system session



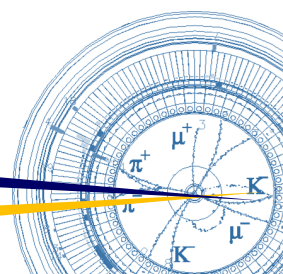


1. Overview
2. IP pipe IP: interaction point
3. QCS pipes QCS : final focusing superconducting magnets system
4. RVC RVC : remote vacuum connection
5. Summary

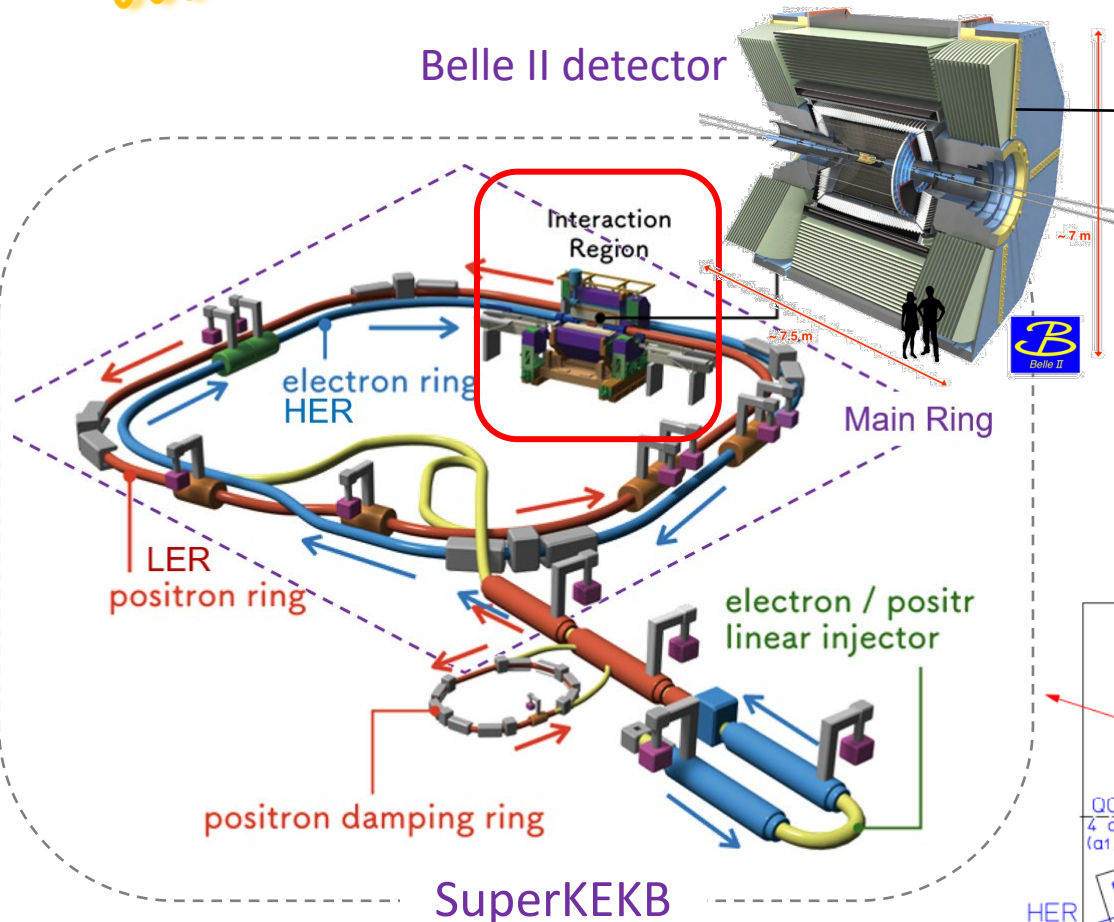
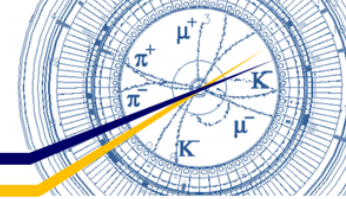
Almost all presentation materials were provided by  
K. Kanazawa(SuperKEKB), S. Tanaka(Belle) and K. Gadov(DESY).



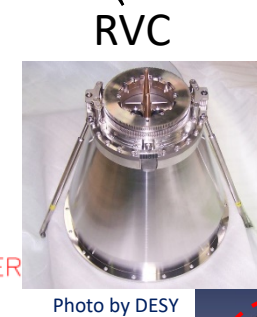
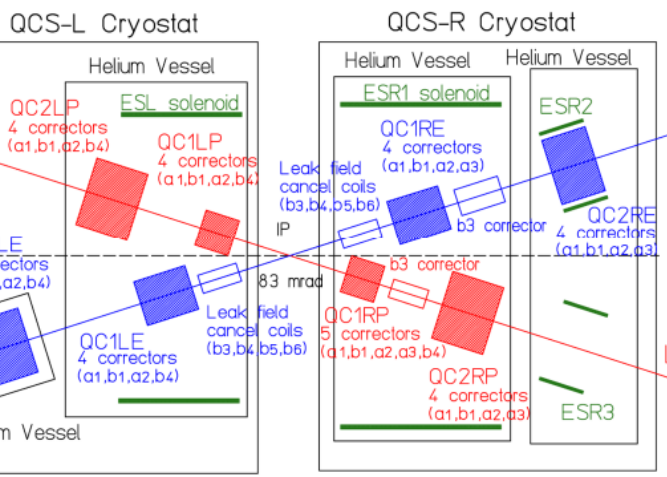
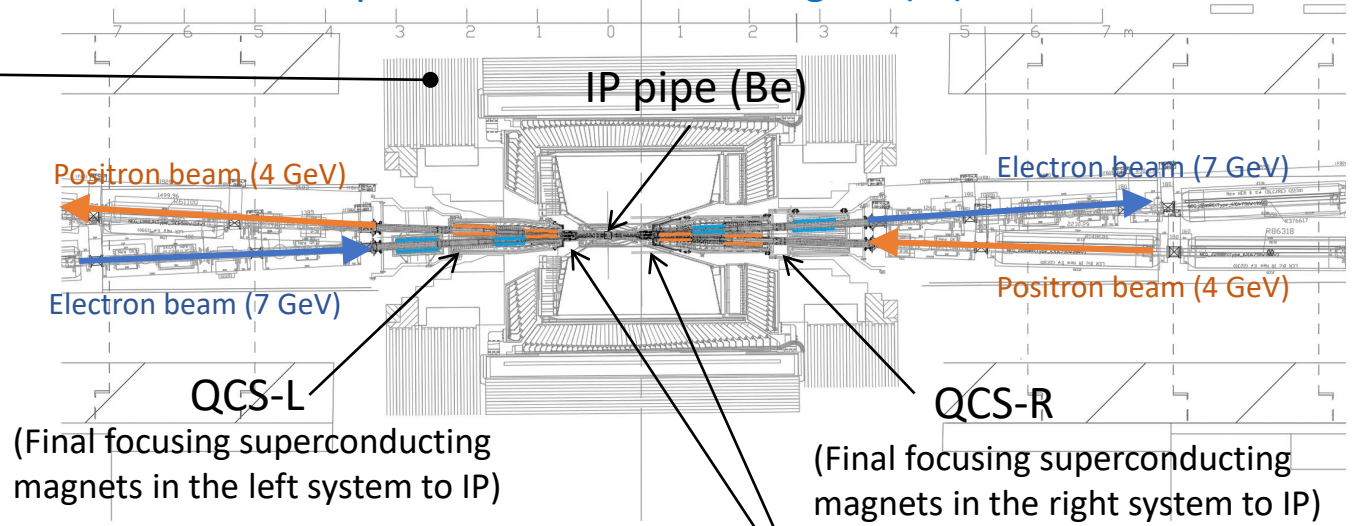
# 1. Overview



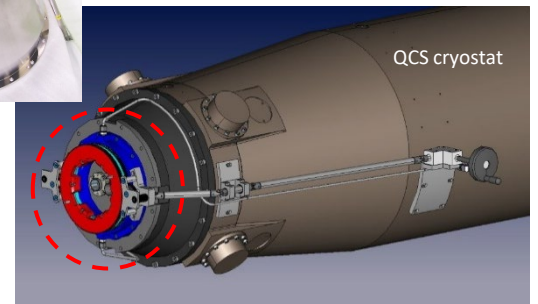
# SuperKEKB interaction region



## SuperKEKB Interaction Region (IR)

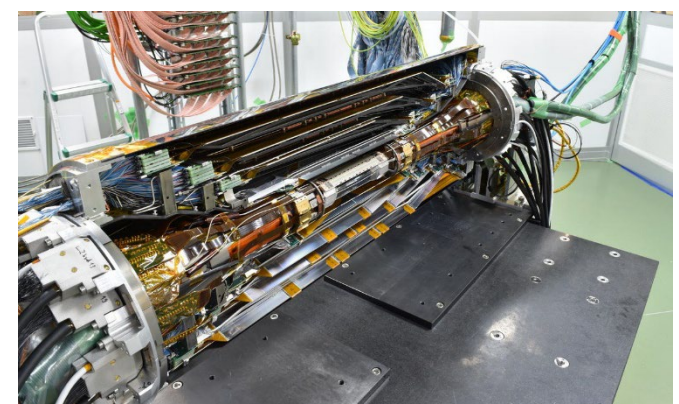
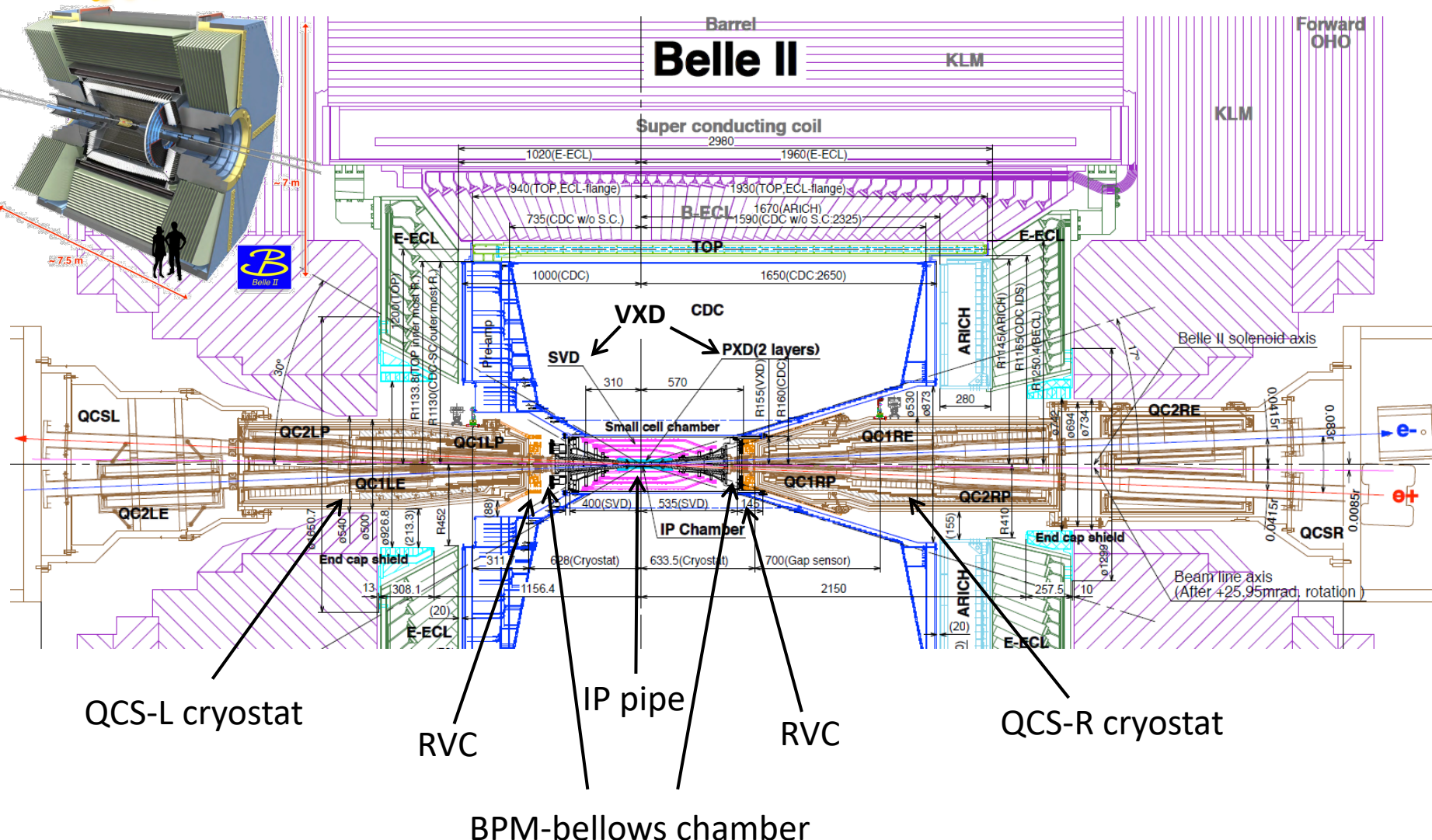
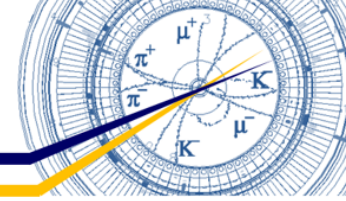


RVC Remote vacuum connection



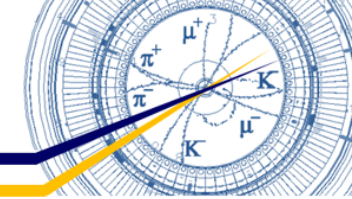
QCS Final focusing superconducting magnet system

# Configuration inside Belle II detector

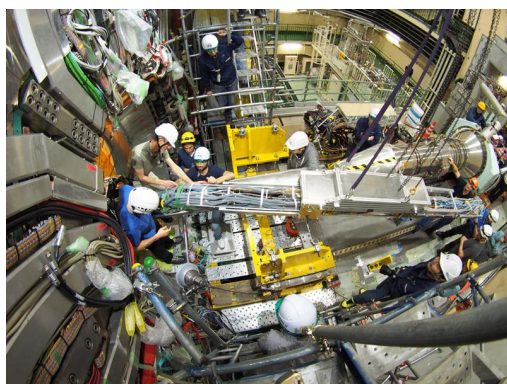
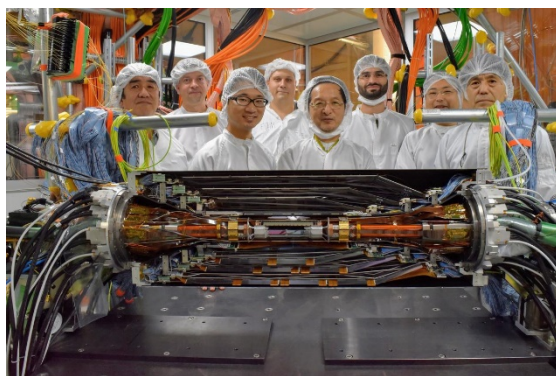


IP pipe assembled with Vertex Detector (VXD)

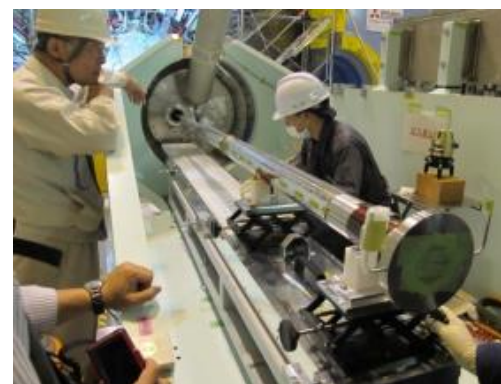
# Installation procedure of IR beam pipes



- 1.1 Assembling IP pipe and VXD
- 1.2 Installing BPM-bellows chambers into both sides of IP pipe
- 1.3 Installing IP pipe assembled with VXD into Belle II

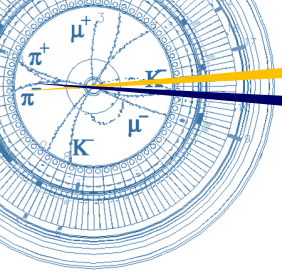


- 2.1 Installing QCS beam pipes into QCS cryostat
- 2.2 Inserting QCS on movable platform into Belle II

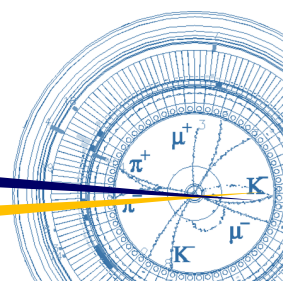


- 3.1 Connecting IP pipe and QCS pipes by RVC
- 3.2 Installing magnets and beam pipes outside movable platform

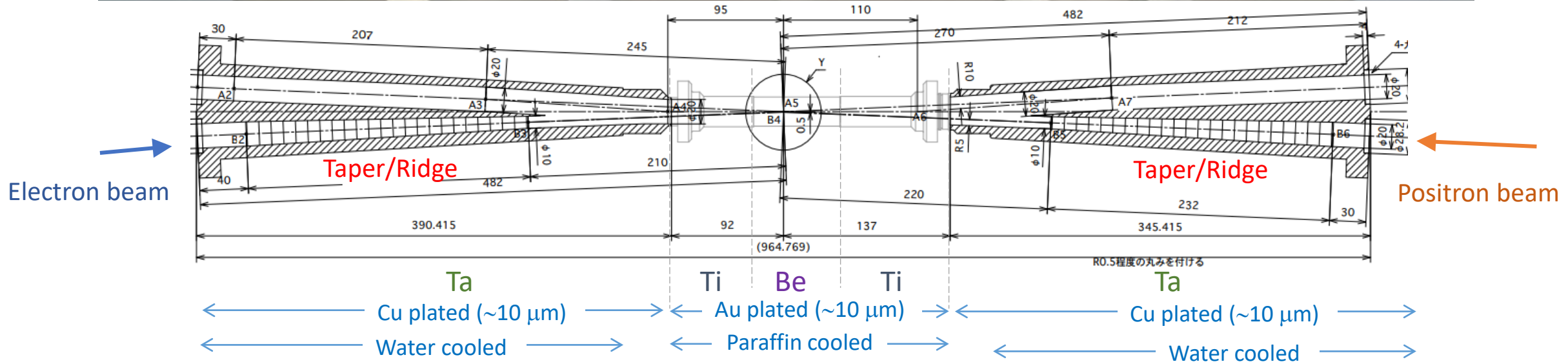
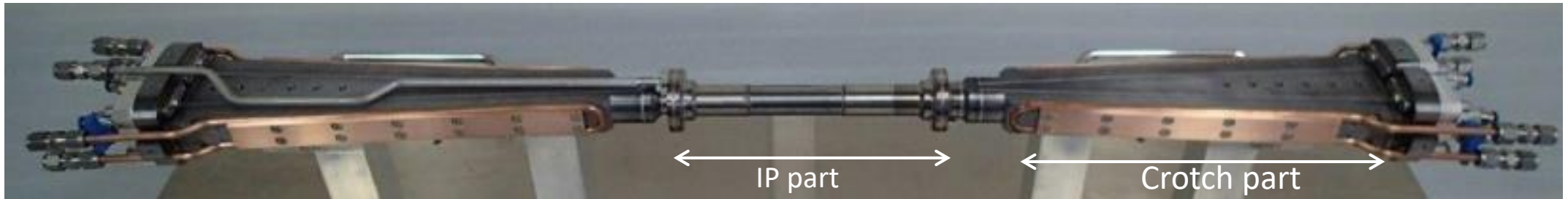
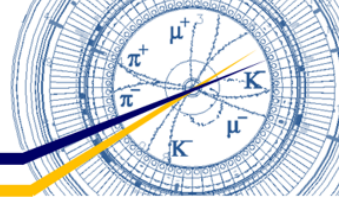




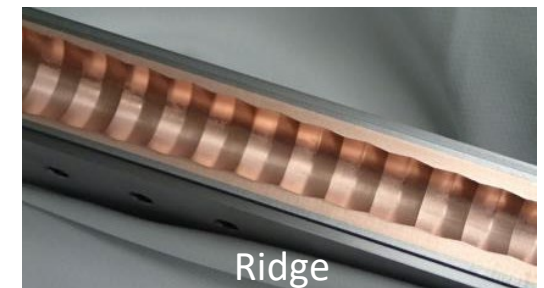
## 2. IP pipe



# IP pipe

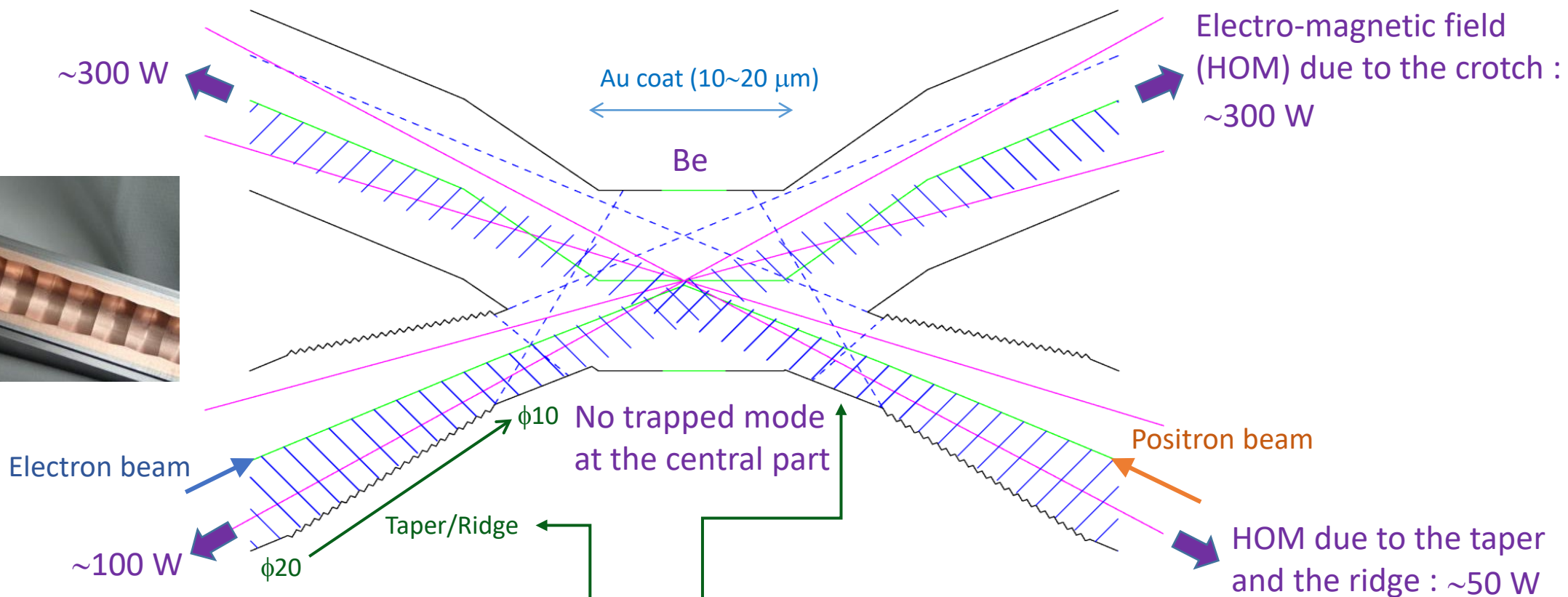
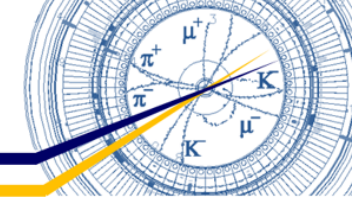


- Central IP part is made of Be and crotch parts are made of Ta.
- Ti is used to connect Be and Ta.
- Only taper parts are exposed to direct SR from last bend.





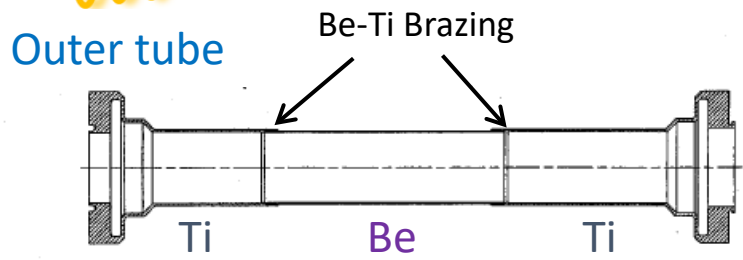
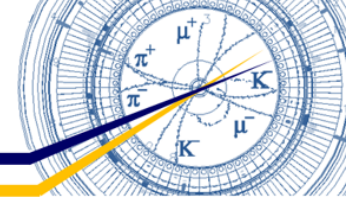
# Synchrotron radiation and Trapped mode



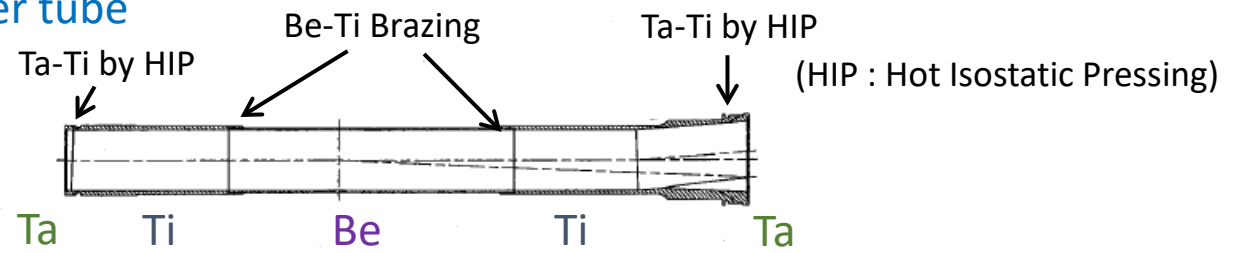
- Taper : to reduce the number of photons entering into the central part
- Ridges : to keep the direction of scattered photons away from Be pipe

- Ridges are omitted to avoid complex machining.
- This part is slightly bent downward (in this drawing) to avoid direct SR hit on Be pipe.

# Central part of IP pipe

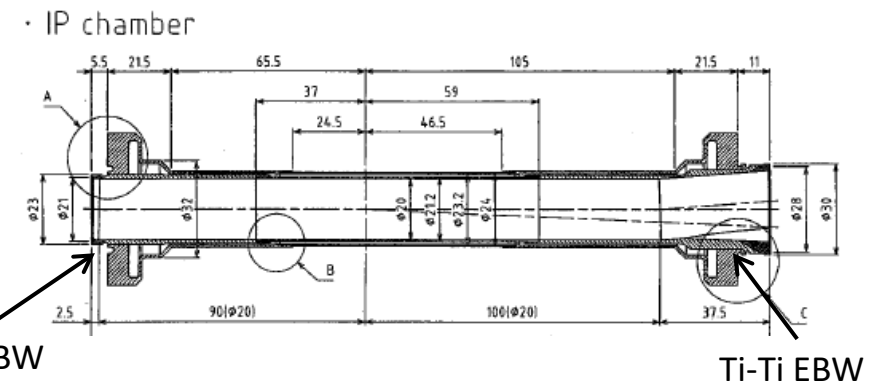


## Inner tube

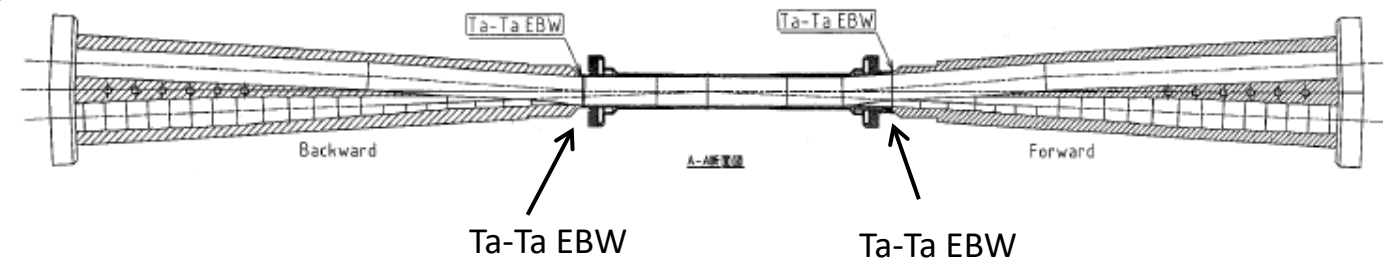


EBW(Ti-Ti)  
・回転方向の位置決め

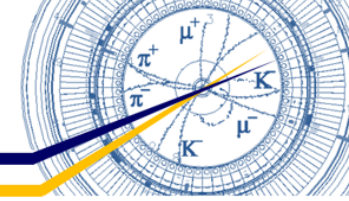
- Outer Be : 0.4 mm thick
- Inner Be : 0.6 mm thick
- Gap : 1 mm



- The central straight part consists of inner and outer tubes.
- Paraffin runs between tubes for cooling.
- Connection between tubes is done by Ti-Ti EBW.
- Connection between IP part and crotch part is done by Ta-Ta EBW.



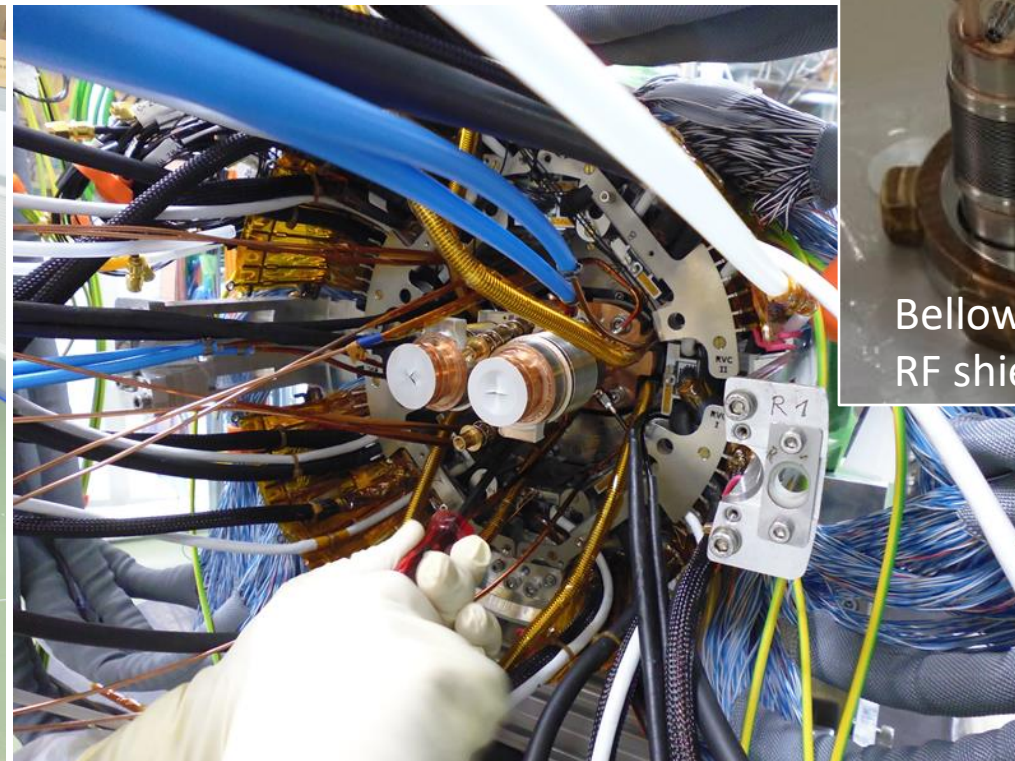
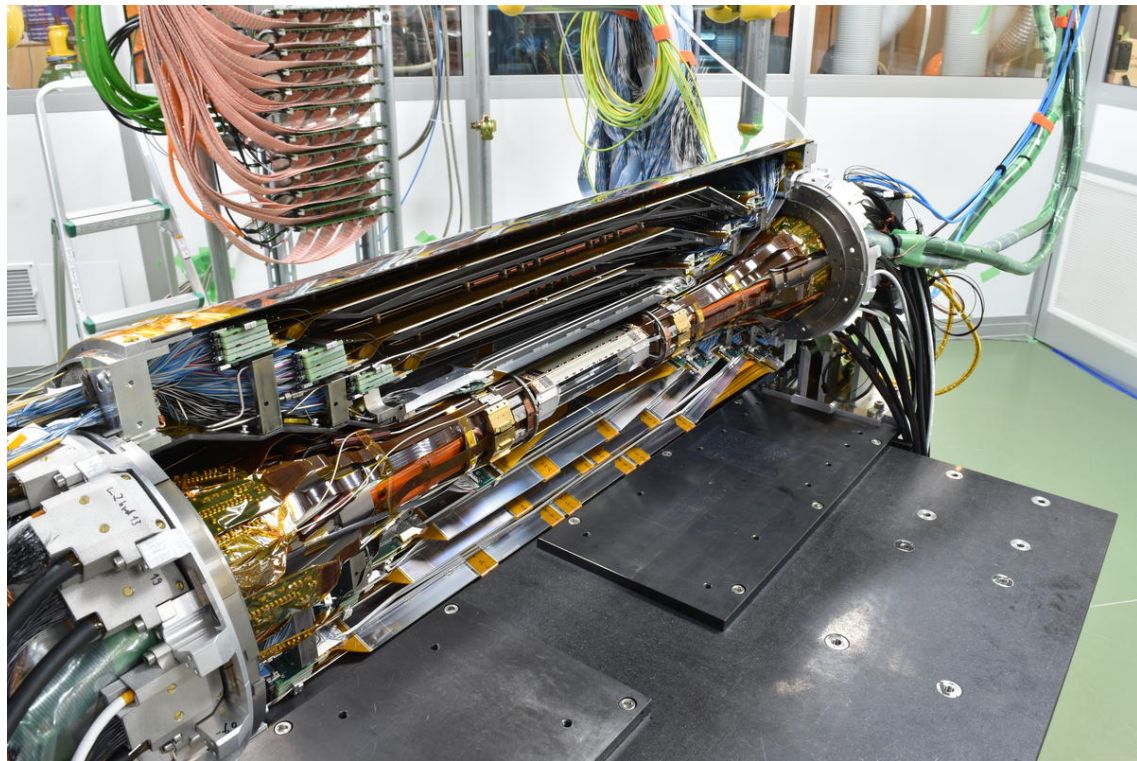
# Installation of IP pipe into Belle II



1.1 Assembling IP pipe and VXD

1.2 Installing BPM-bellows chambers into both sides of IP pipe

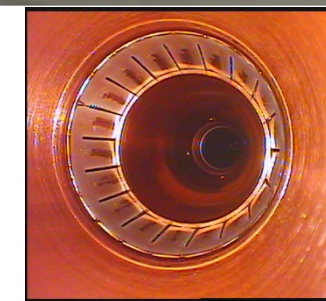
1.3 Installing IP pipe into Belle II



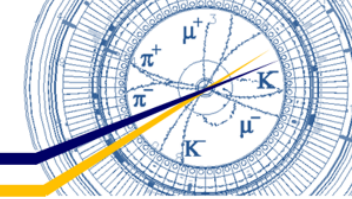
BPM



Bellows with finger-type RF shield



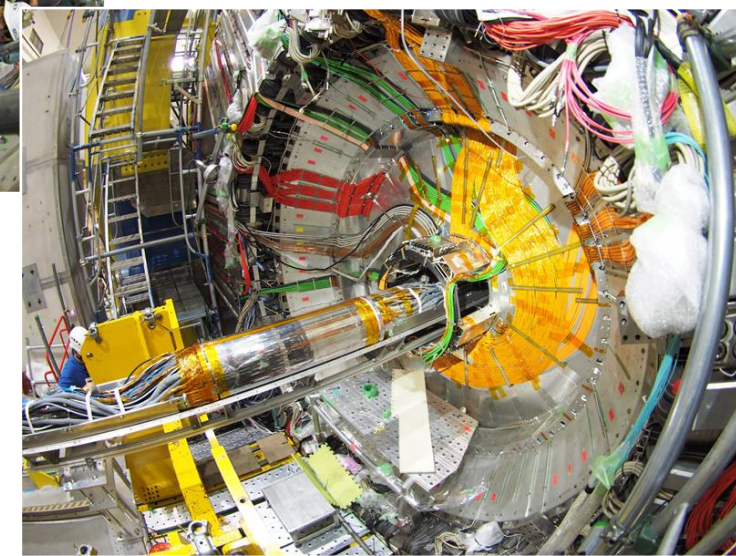
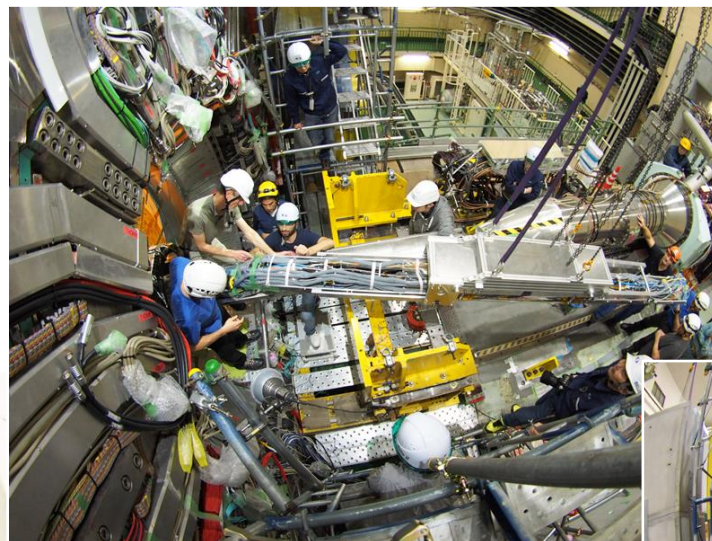
# Installation of IP pipe into Belle II



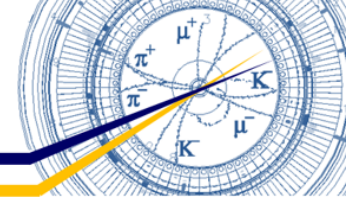
1.1 Assembling IP pipe and VXD

1.2 Installing BPM-bellows chambers into both sides of IP pipe

1.3 Installing IP pipe into Belle II



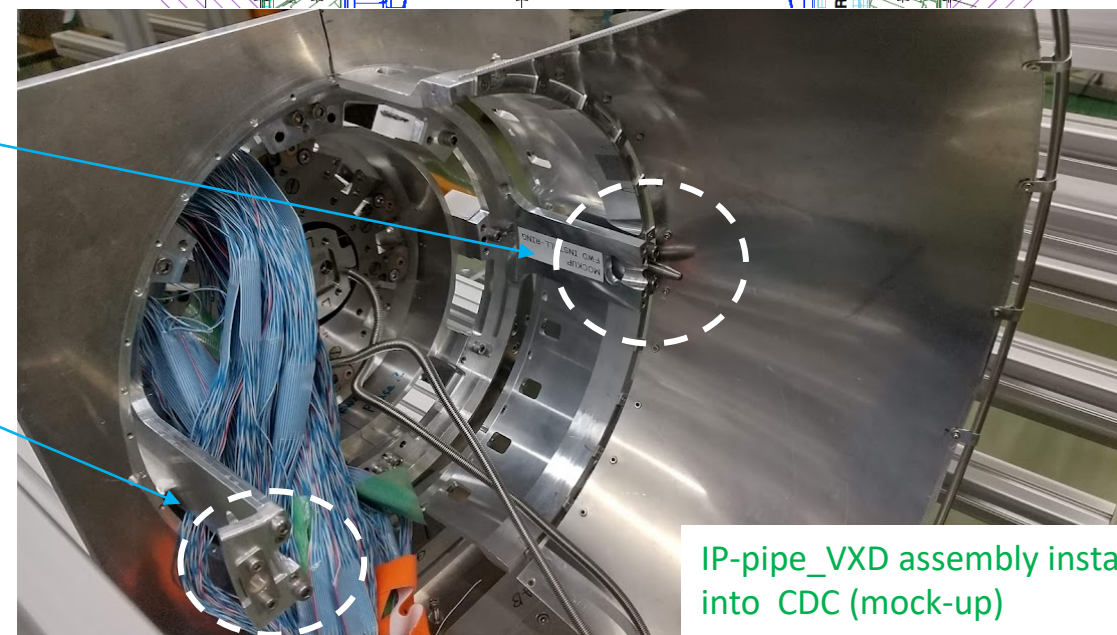
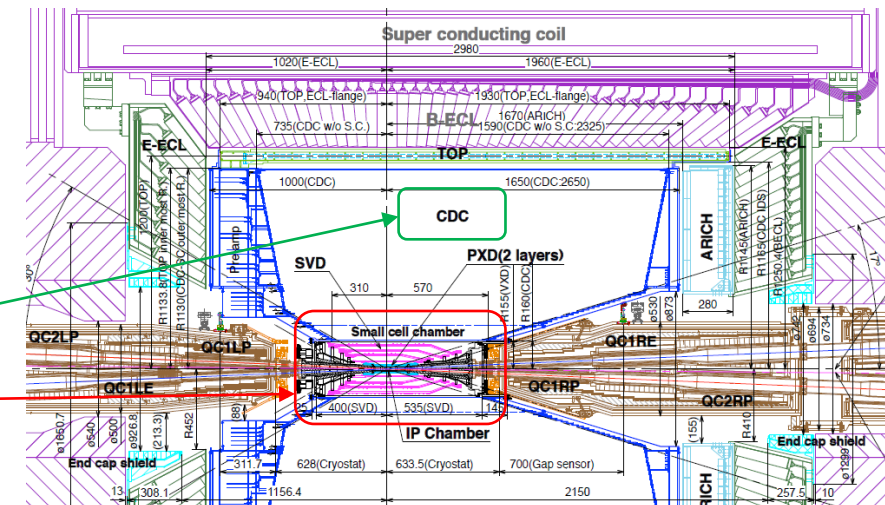
# Installation of IP pipe into Belle II



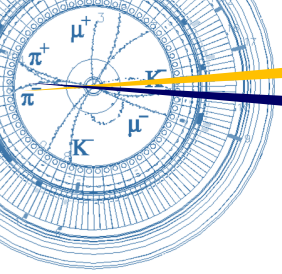
- 1.1 Assembling IP pipe and VXD
- 1.2 Installing BPM-bellows chambers into both sides of IP pipe
- 1.3 Installing IP pipe into Belle II

- IP pipe alignment

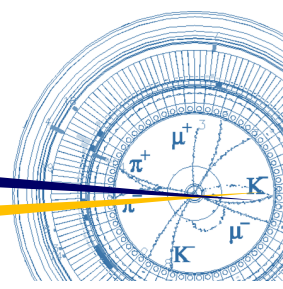
- IP-pipe\_VXD assembly is mounted on CDC.
- Location of IP-pipe\_VXD assembly is determined by CDC positioning pins.
- Position of CDC positioning pins are measured by laser tracker before installation of IP-pipe\_VXD assembly.
- Pin holes of IP-pipe\_VXD assembly are positioned so that the IP pipe can be installed in the proper position for the accelerator.
- Position of VXD is estimated from particle track data.



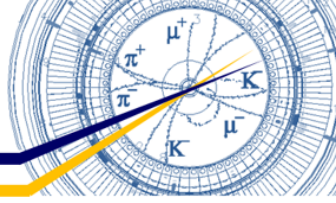
IP-pipe\_VXD assembly installed into CDC (mock-up)



# 3. QCS pipes

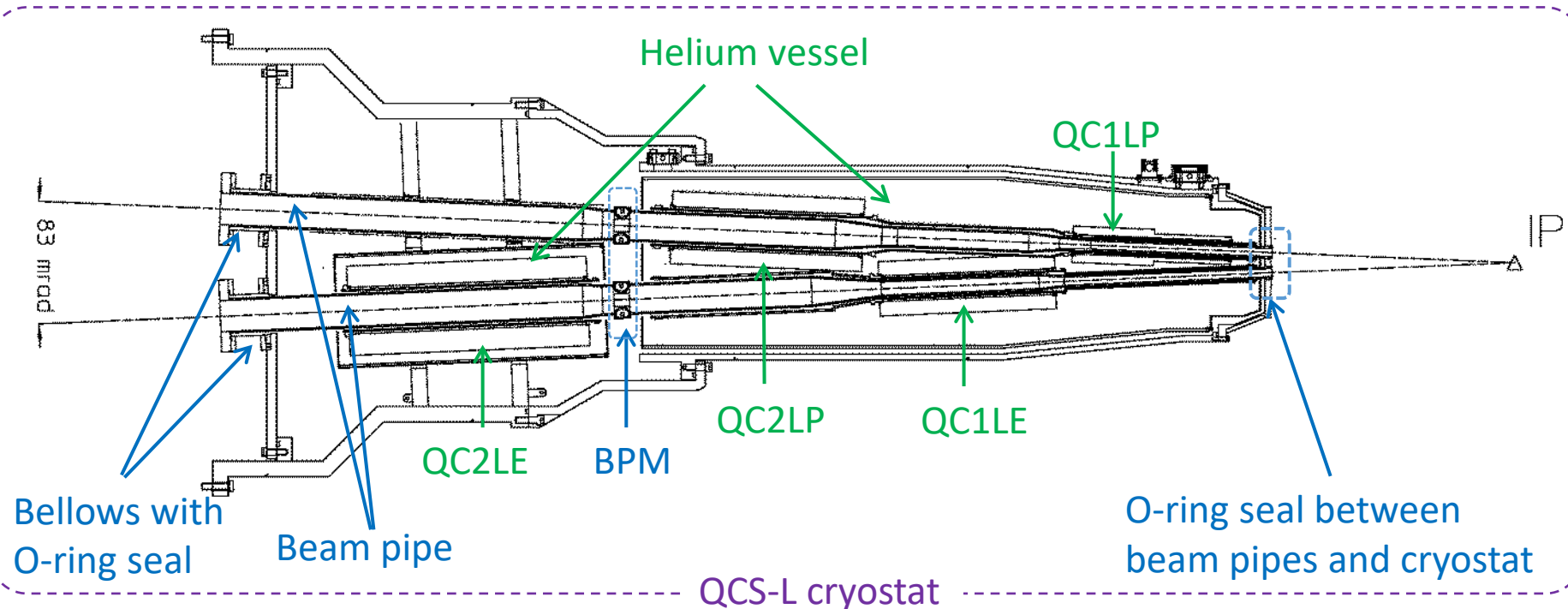
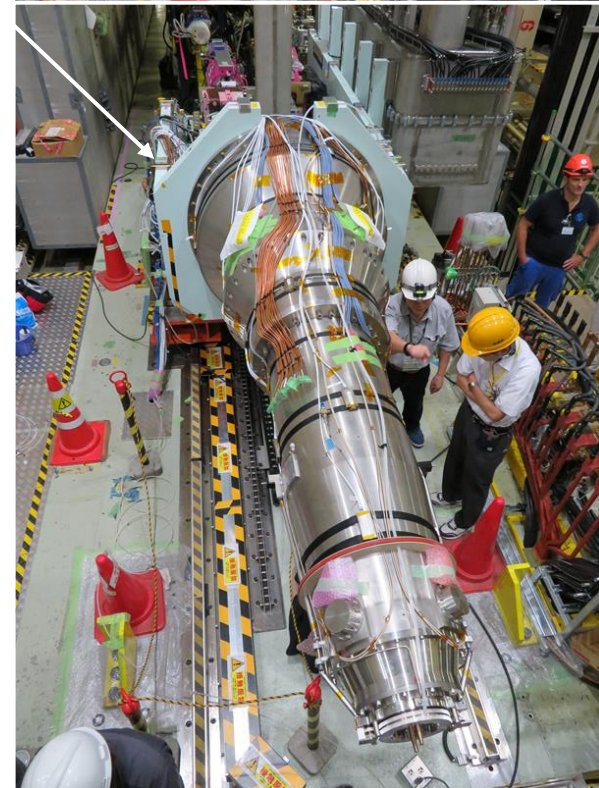


# Beam pipes for QCS

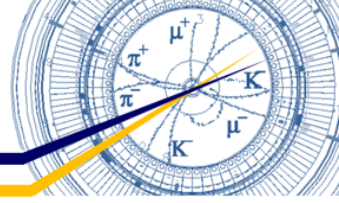


- Beam pipes are fixed to QCS cryostat.
- They are made of stainless steel with a 4 mm thick wall.
- They have water cooling channels on both sides.
- Inner surface is coated with Cu (+ TiN only for positron ring).

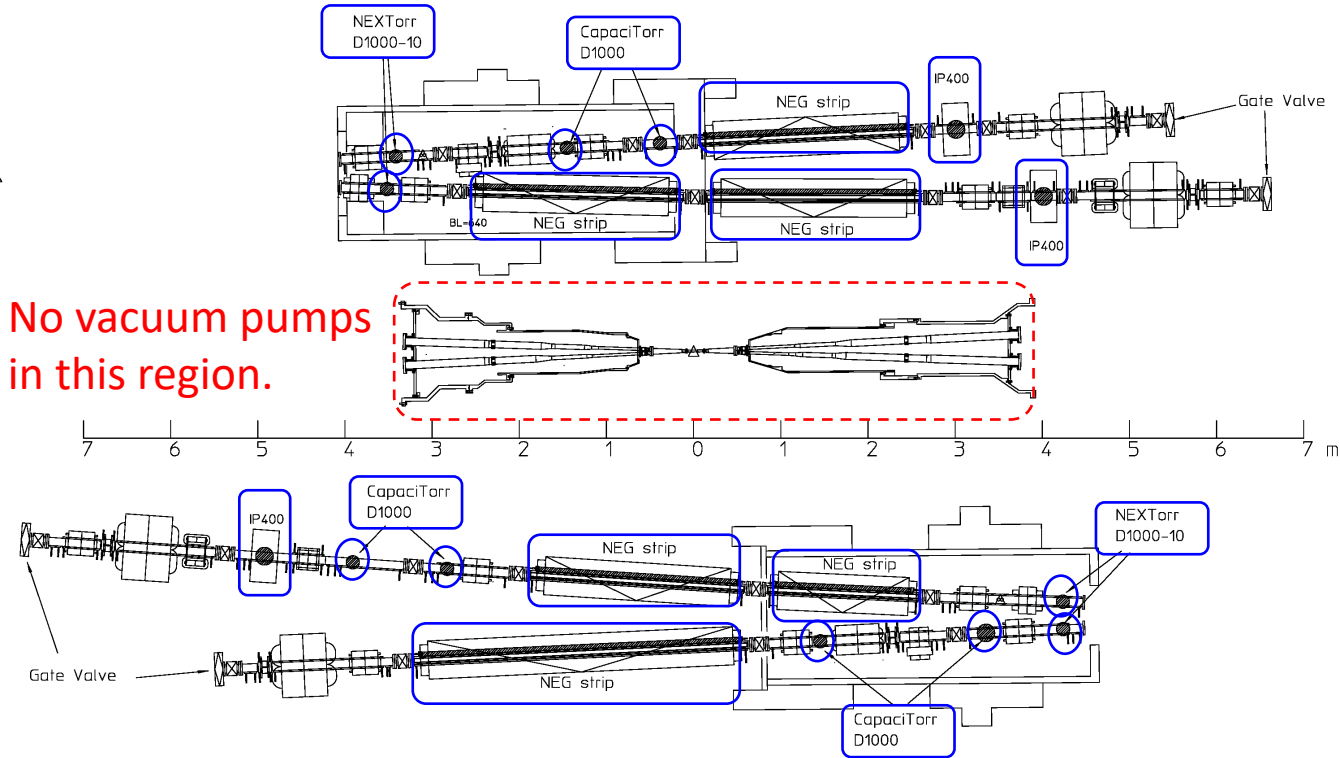
Movable platform



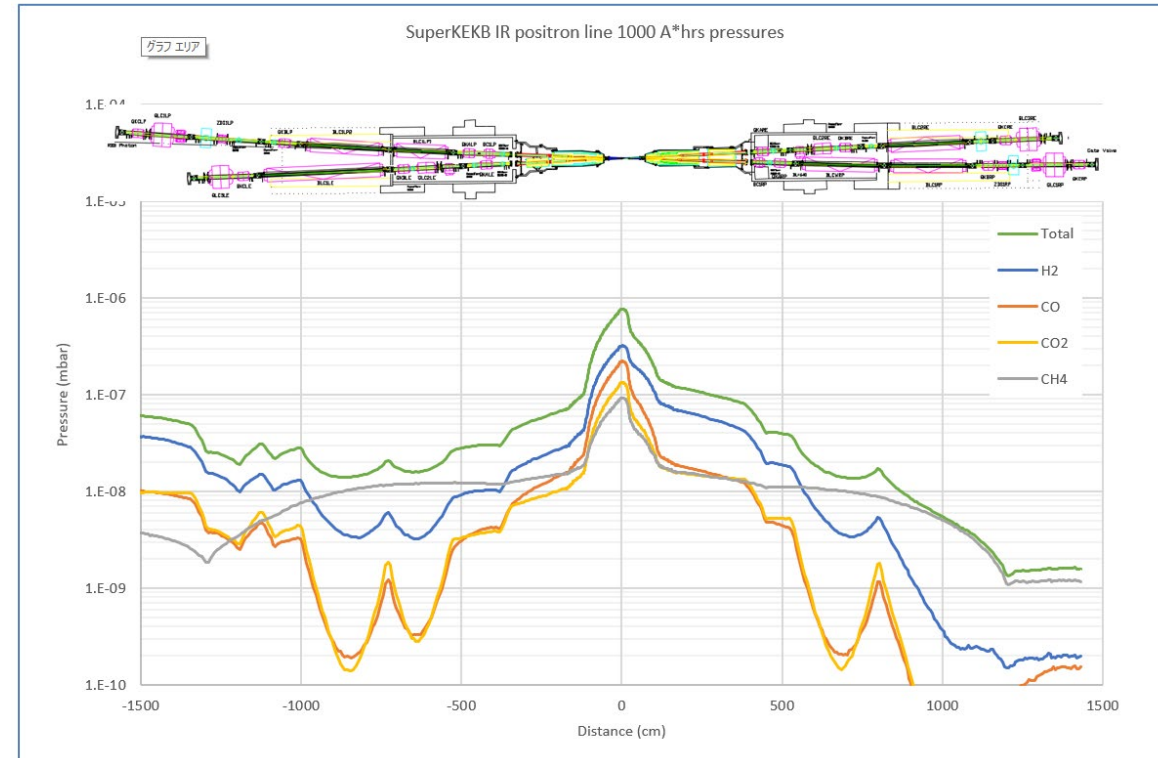
# IR pressure distribution



- IP pipe and QCS beam pipes have no pump.
- Pressure at IP is estimated to be about one order higher than that at the end of the cryostat.

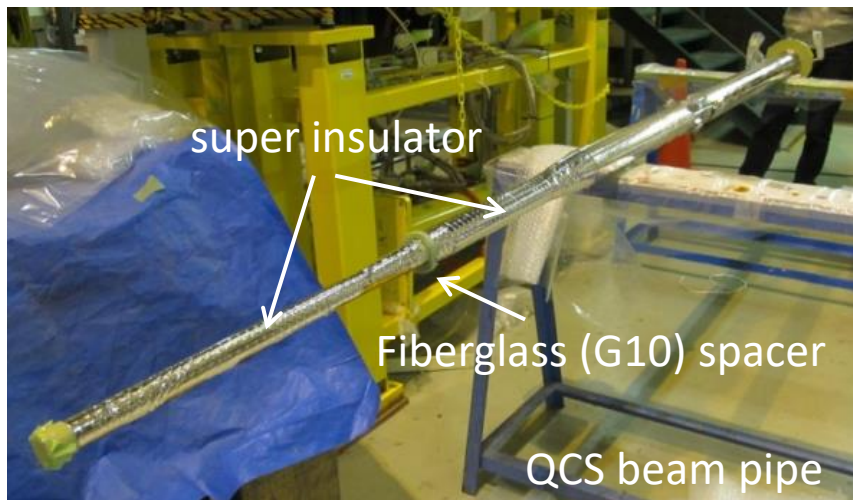
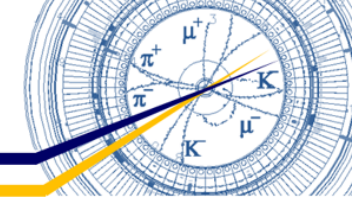


Thanks to J. Carter (ANL), M. Ady, R. Kersevan, and P. Chiggiato (CERN)





# QCSR beam pipe installation



- Installation procedure :

1. Set beam pipe



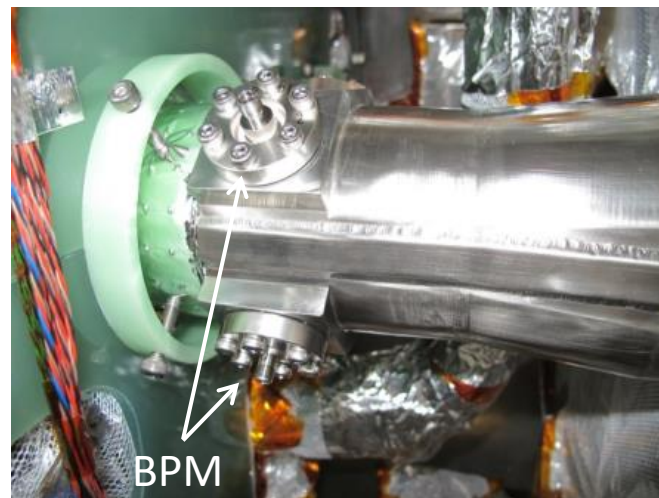
2. Attach BPM and leak check



3. Connect BPM cable



4. Leak check of the cryostat



- Beam pipe is inserted using a special tool.
- Service window on QCSR cryostat is used to manually guide the beam pipe and to attach BPM.

Photo by Y. Arimoto

# QCSL beam pipe installation

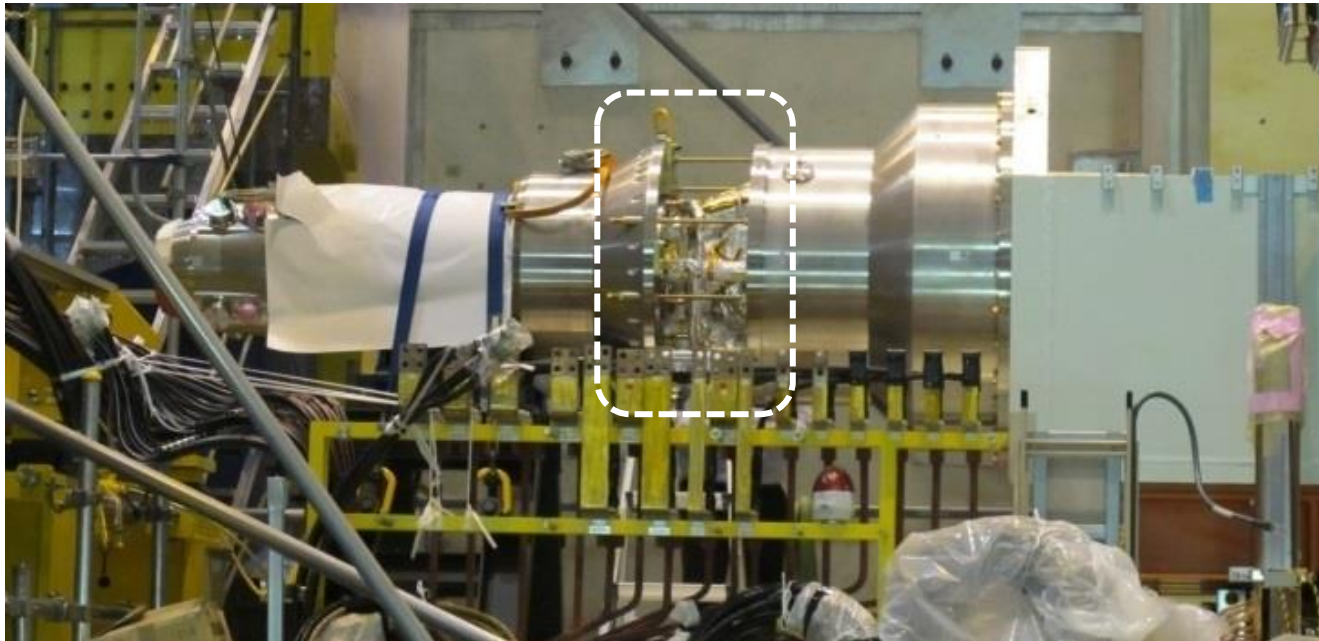
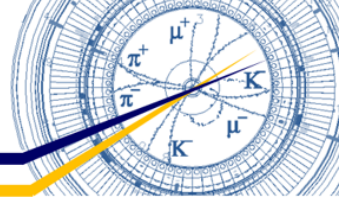
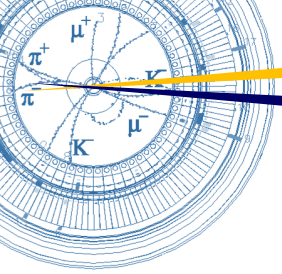
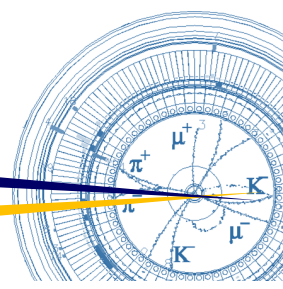


Photo by Y. Arimoto

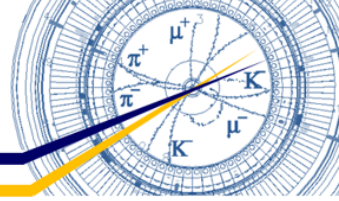
- Since QCSL cryostat has no service windows, **the cryostat is disassembled** for beam pipe installation.



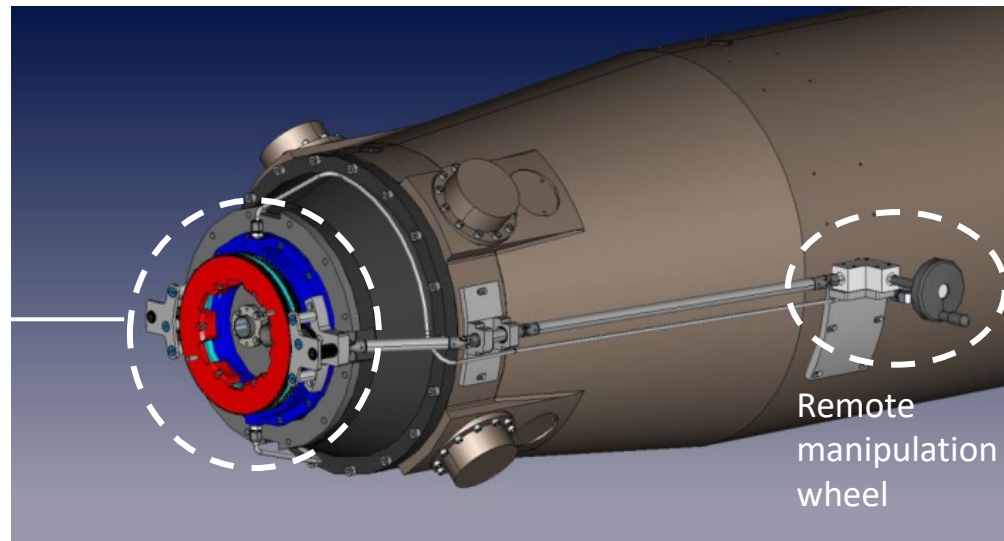
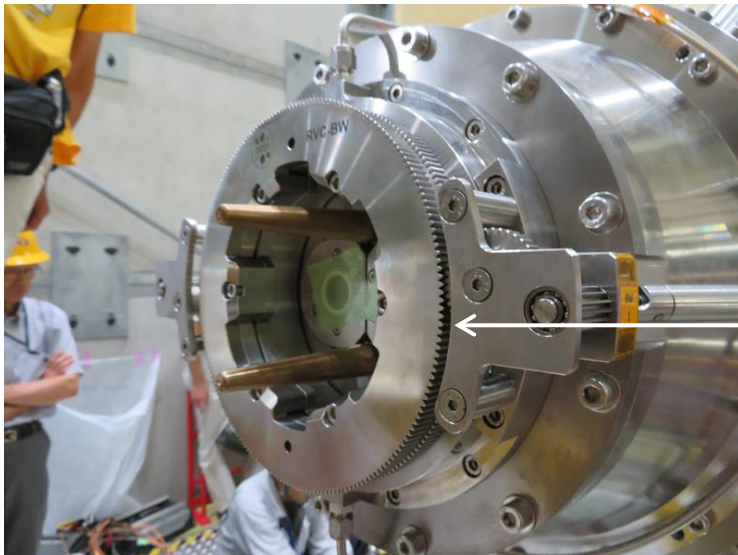
# 4. RVC



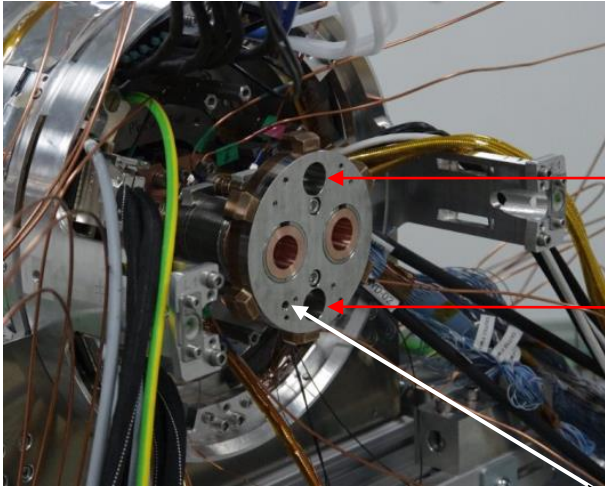
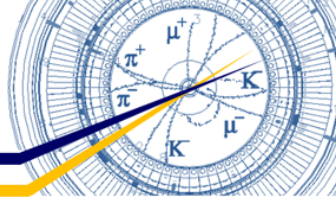
# Remote vacuum connection (RVC)



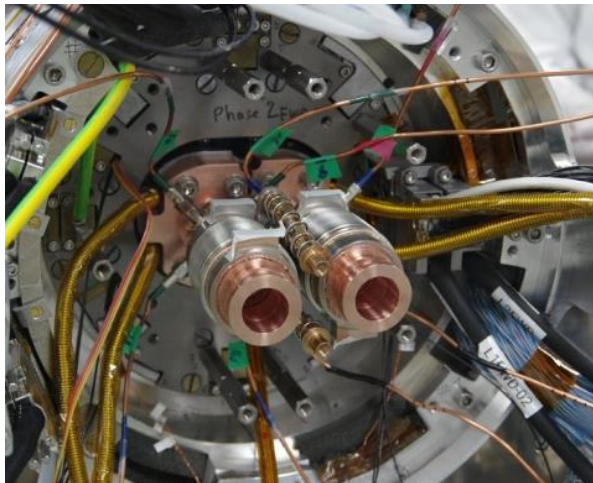
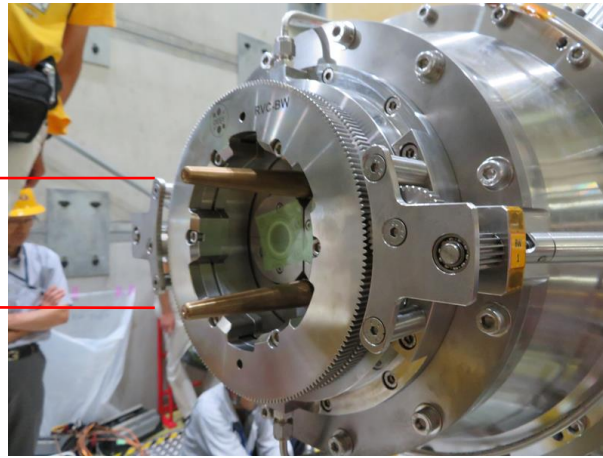
- QCS is inserted into Belle II by movable platform and connected to IP pipe.
- There is no space for vacuum sealing work by hands.
- RVC is a mechanism introduced by Belle group to connect QCS beam pipes to IP pipe (BPM-bellows chambers) by a remote manipulation.
- RVC was designed and produced by DESY.



# How RVC works

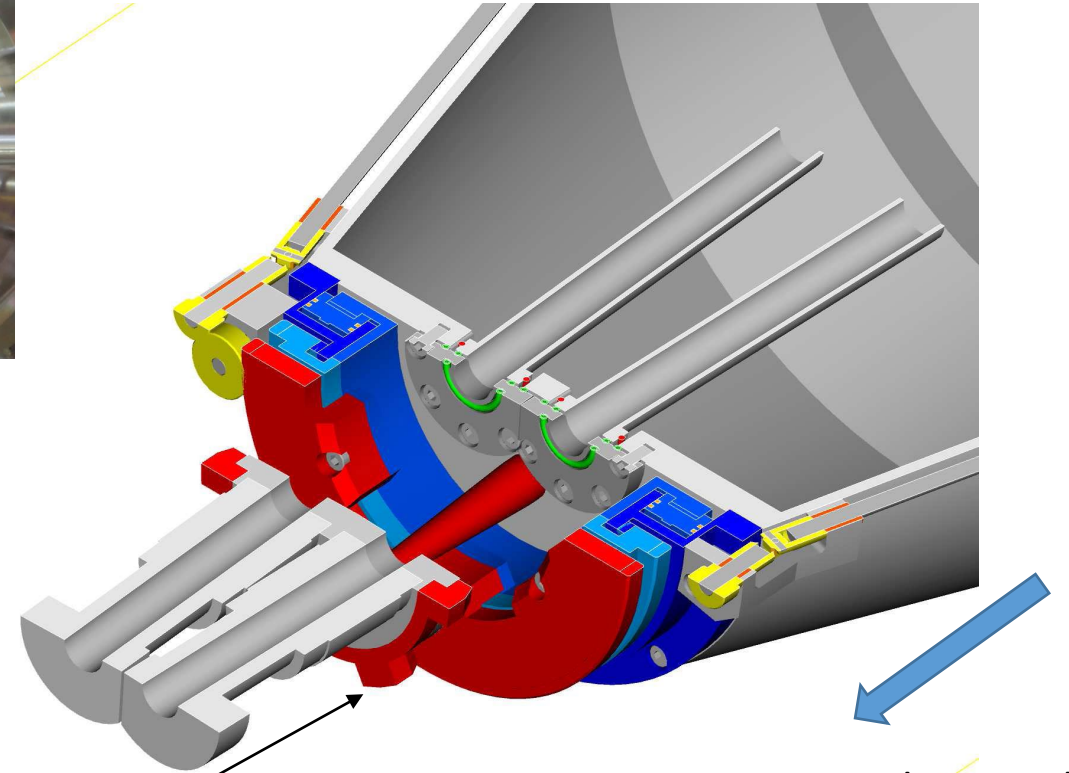


BPM-bellows w/ lock flange



BPM-bellows w/o lock flange

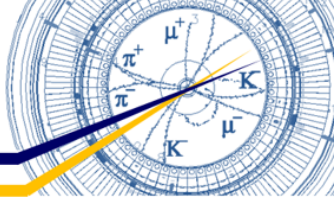
Drawing by K. Gadow



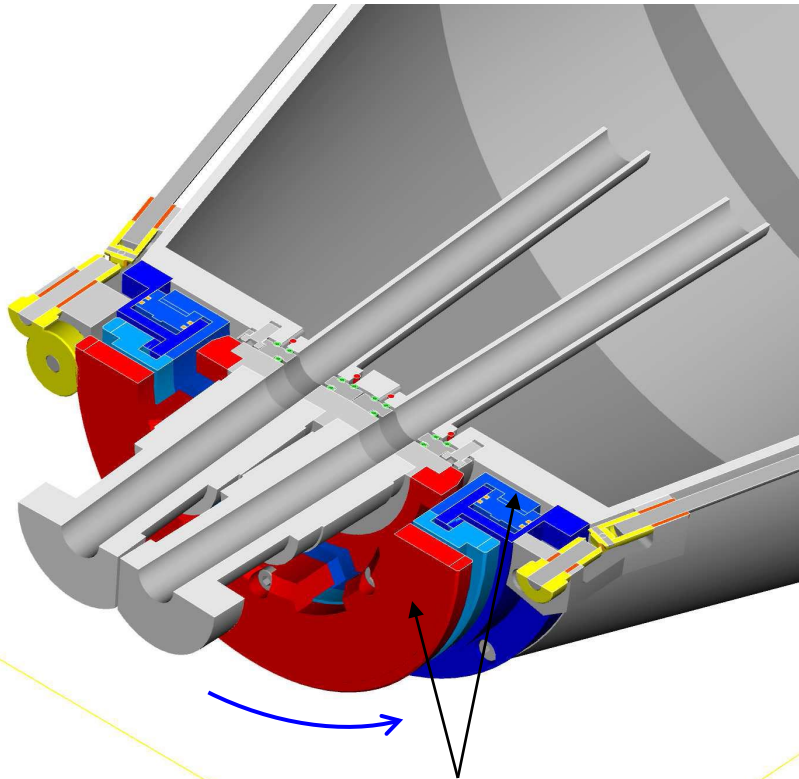
QCS is inserted into Belle II.

Single lock flange with a retainer is attached to two bellows units.

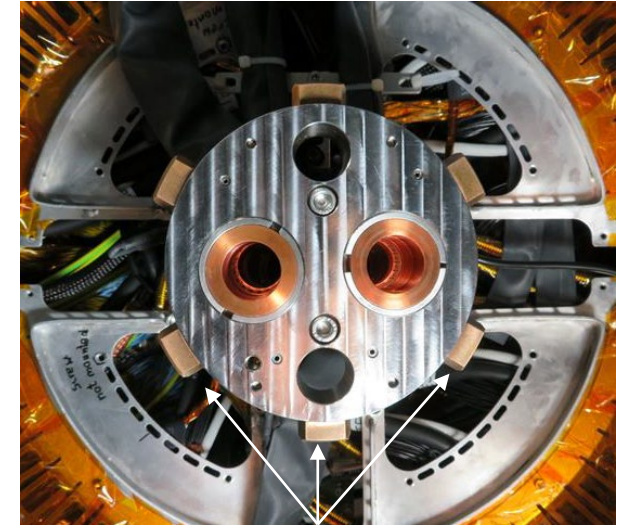
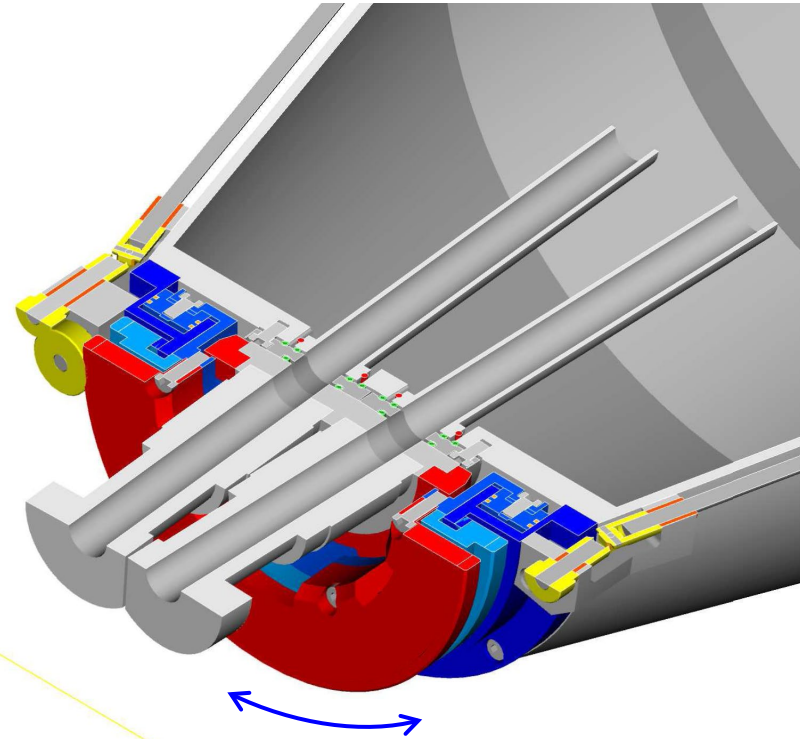
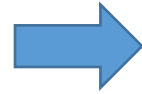
# How RVC works



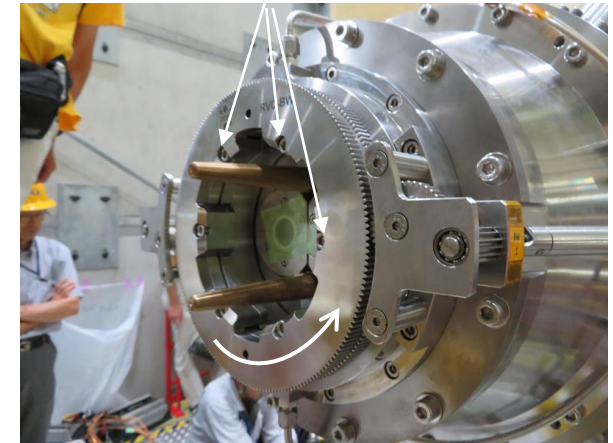
Drawing by K. Gadow



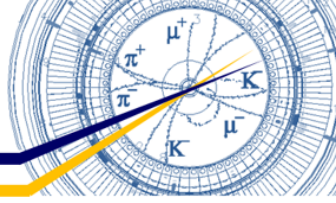
These components (red+blue) rotate to catch the lock flange.



Protruding claws of the lock flange are caught by RVC.



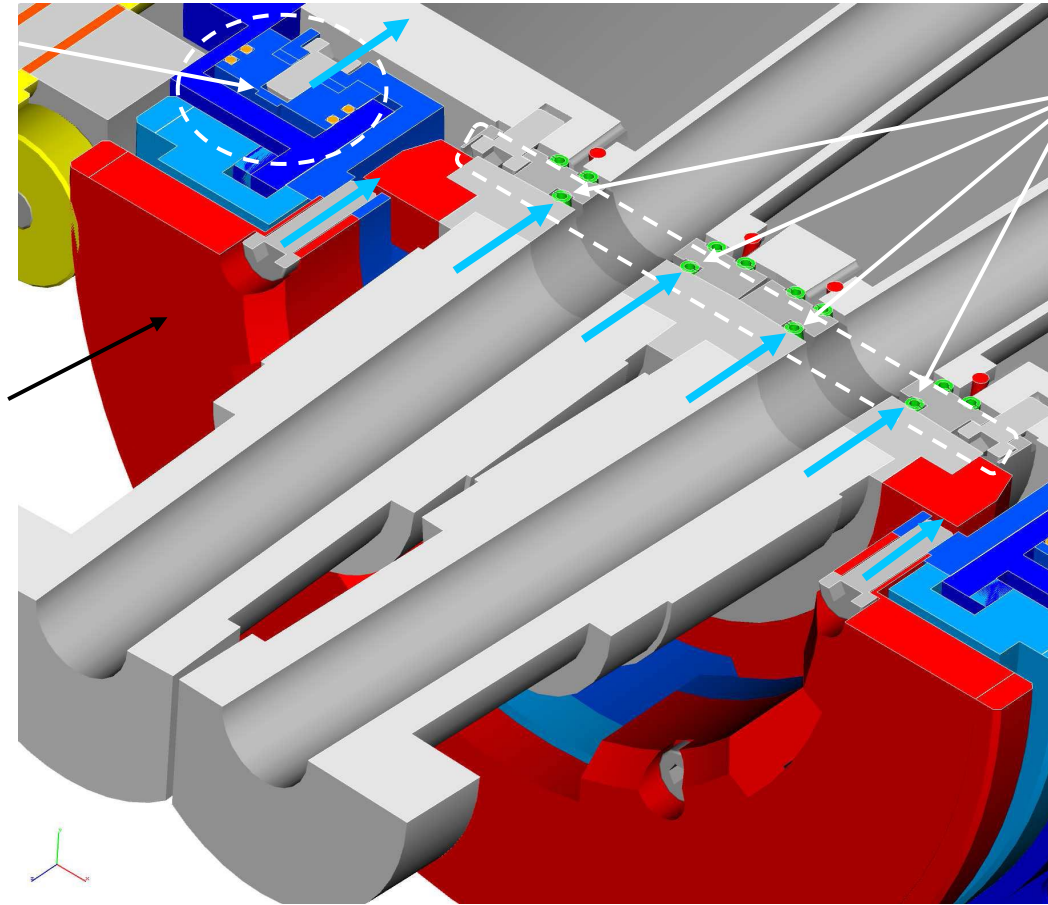
# How RVC works



Drawing by K. Gadow

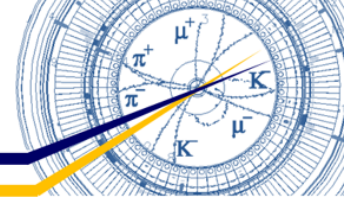
Cylinder for dry N<sub>2</sub> (about 50 bar)  
High pressure N<sub>2</sub> gas is introduced into this volume.

These parts are connected to the piston in the cylinder, and shift to press the bellows flange to the cryostat.

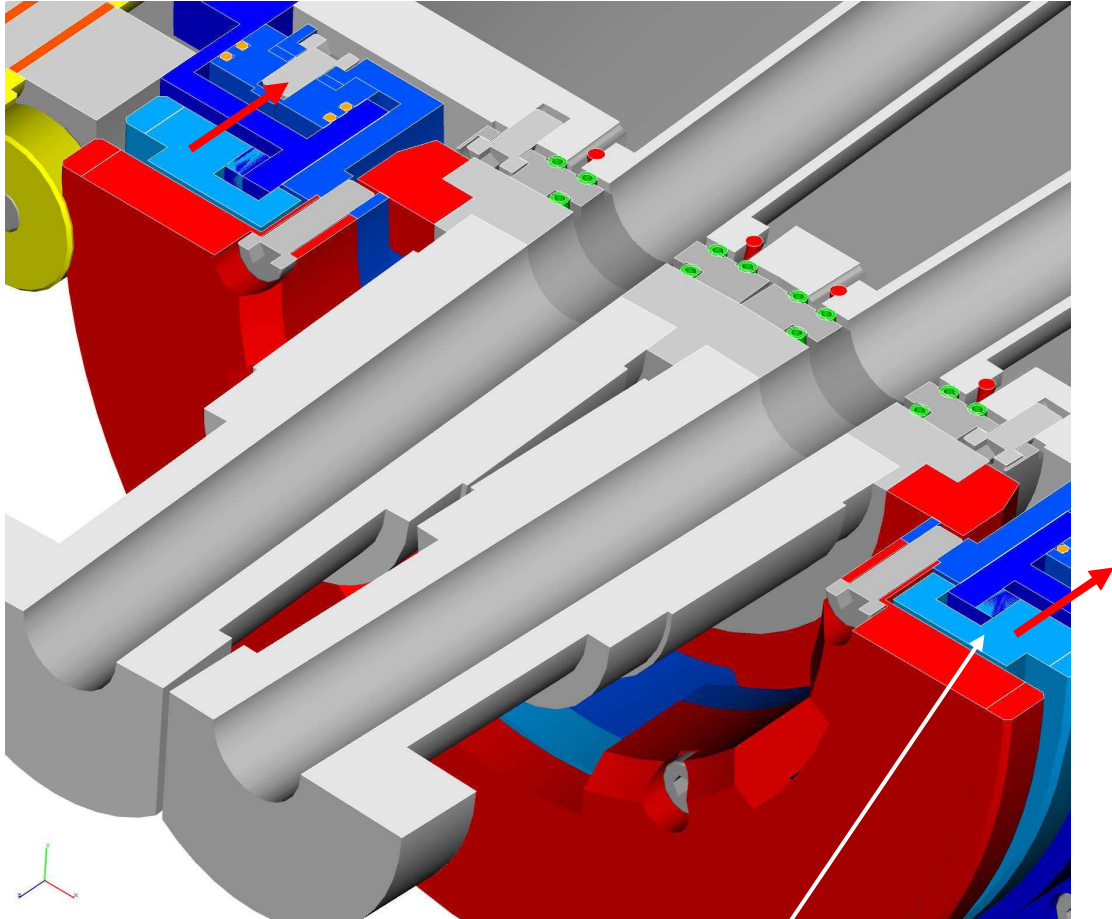


As a result, vacuum sealing between IP pipe (BPM bellows chamber) and QCS pipe is completed.

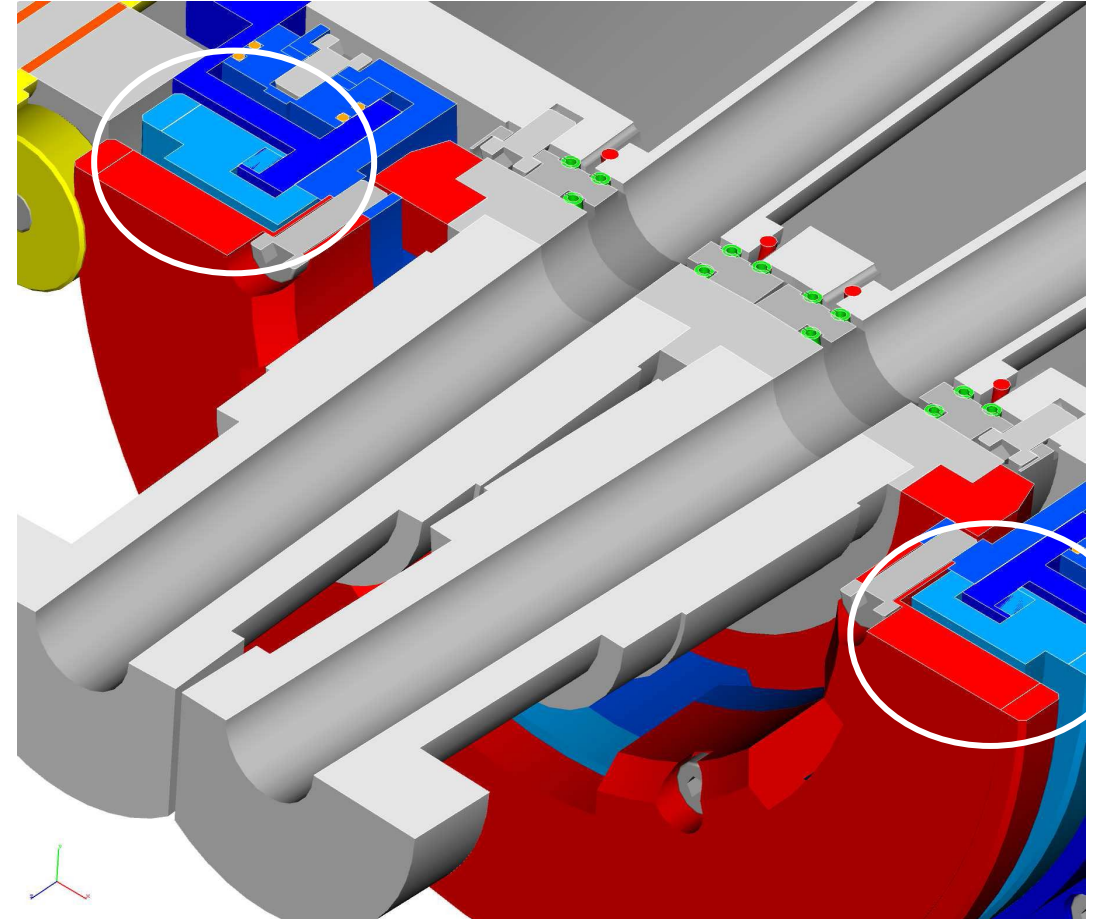
# How RVC works



Drawing by K. Gadow



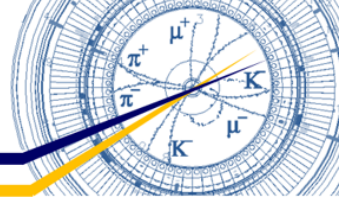
This large light blue screw nut turns to lock the mechanism.



Completed!!

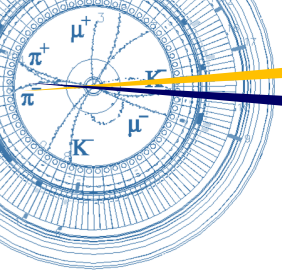


# IR exterior appearance

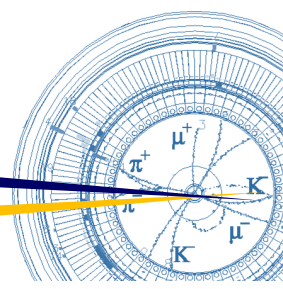


- Finally concrete radiation shields cover accelerator components.

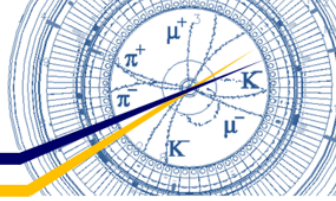




# 5. Summary

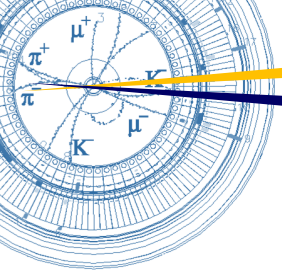


# Summary

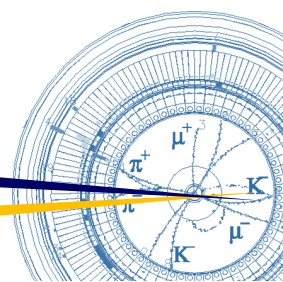


- IP pipe;
  - IP pipe consists of Be (center), Ti and Ta (crotch) parts.
  - Central Be pipe is not exposed to direct SR.
  - Crotch part has taper and ridge structures to reduce the number of photons entering into the central part.
  - IP pipe is assembled with VXD and installed into Belle II.
- QCS pipes;
  - SUS pipes are fixed to QCS cryostat and inserted into Belle II by QCS movable platform.
  - QCS pipes have no pump
  - Pressure at IP is estimated to be about one order higher than that at the end of the cryostat.
- RVC;
  - RVC is a mechanism introduced by Belle group to connect QCS pipes to IP pipe by a remote manipulation.
  - RVC was designed and produced by DESY.





Fin.



Thank you for your attention.



# Backup

