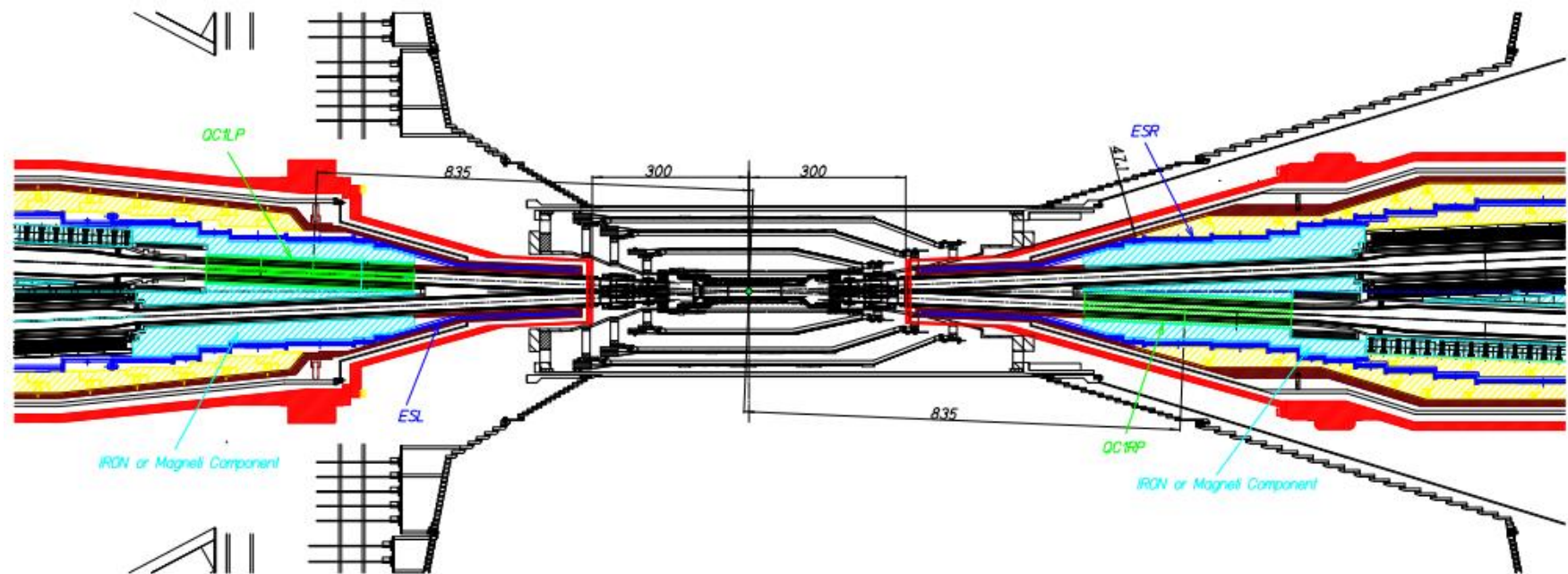


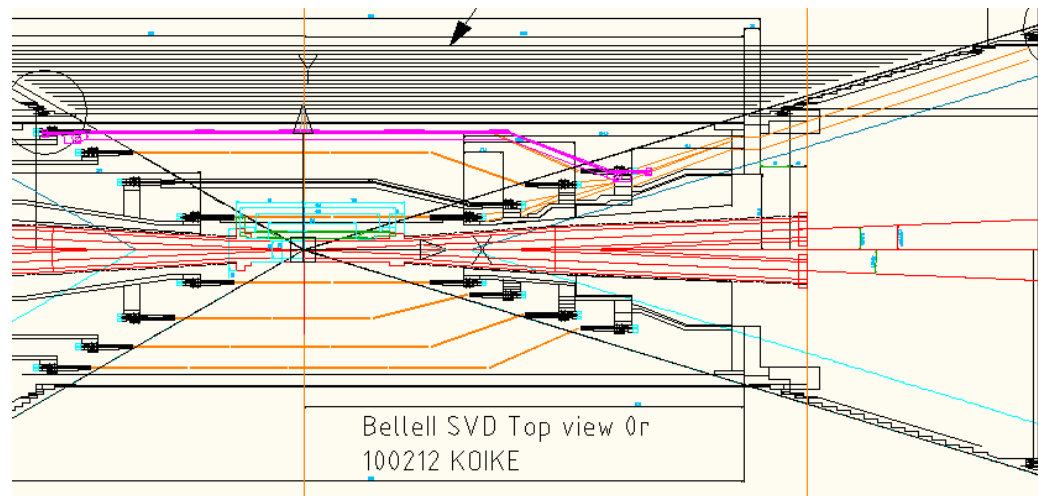
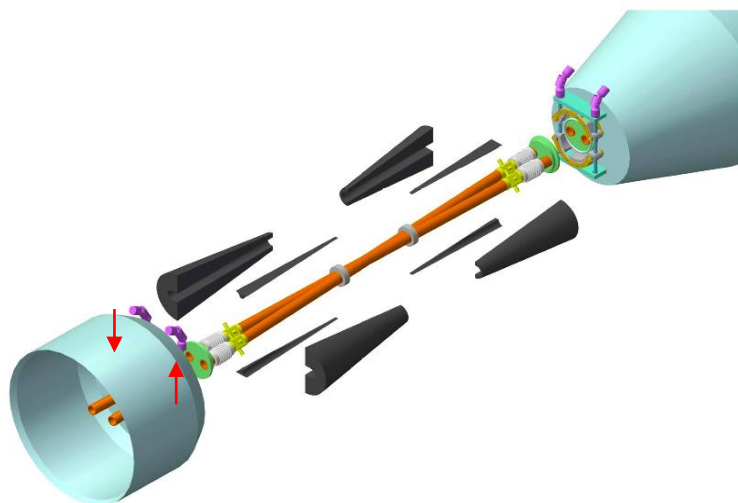
# Material for the beam pipe discussion (S. Tanaka KEK)

## New Cryostat



# SuperKEKB IR design timeline

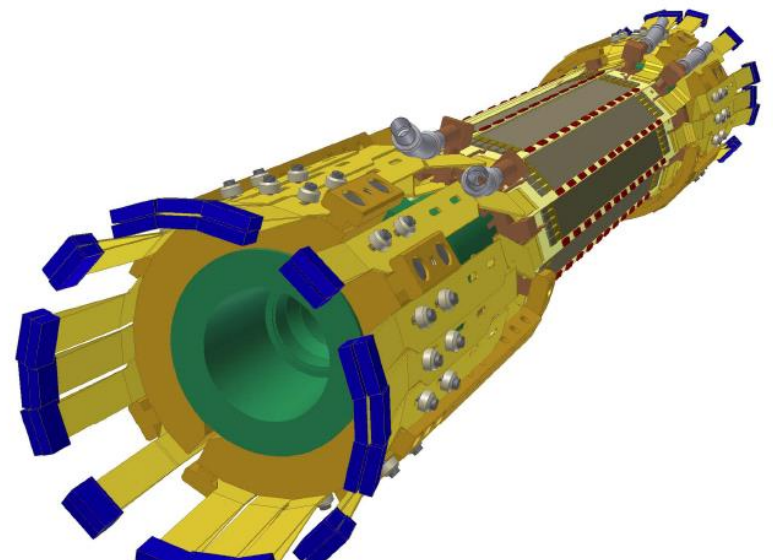
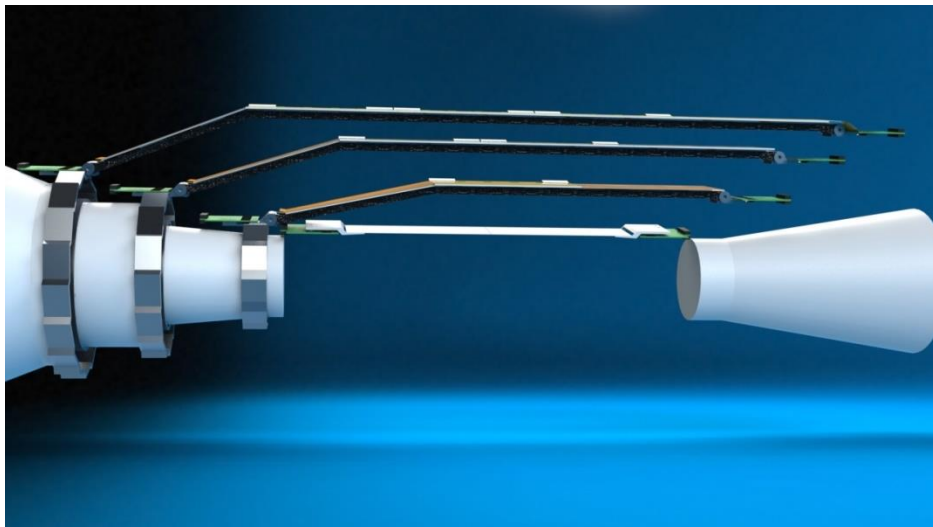
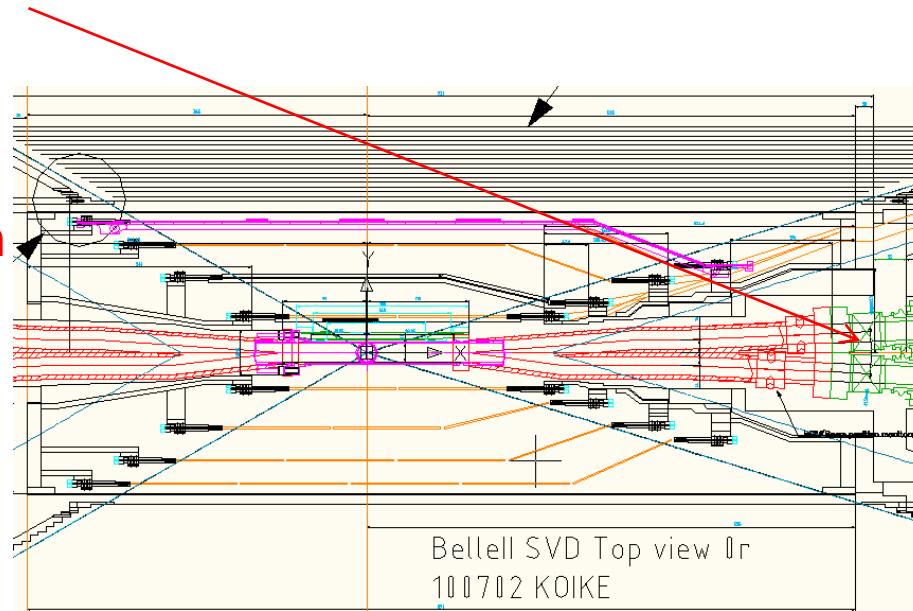
- 2009 Nov(4<sup>th</sup> B2GM): Nano-beam scheme has decided
  - (Up to this B2GM, machine group chair the session)
  - QCS magnets BPM, bellows pipe allocation is defined
  - Pressure estimation around IP chamber
- 2010 Mar.(5<sup>th</sup> B2GM) First draft design around VXD



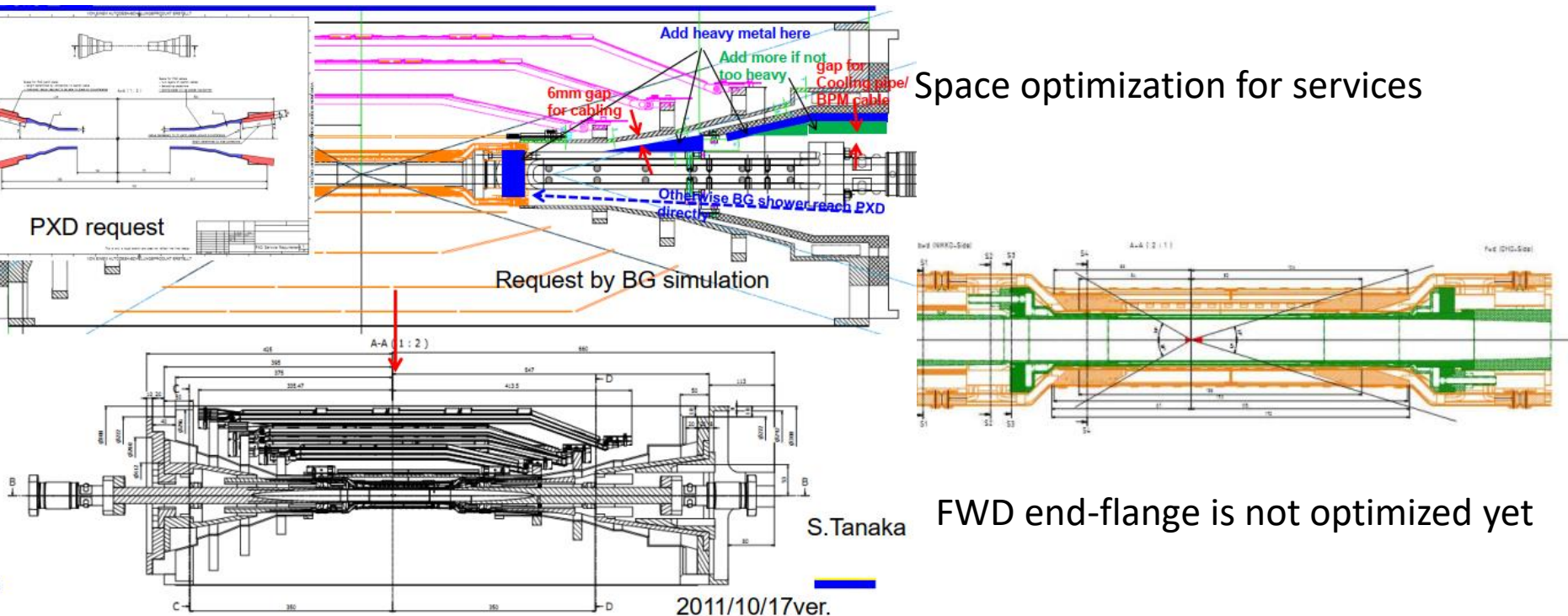
**vertical division case**

IP pipe ; Kanazawa, I  
IR integration : Kohriki  
VXD design: Koike

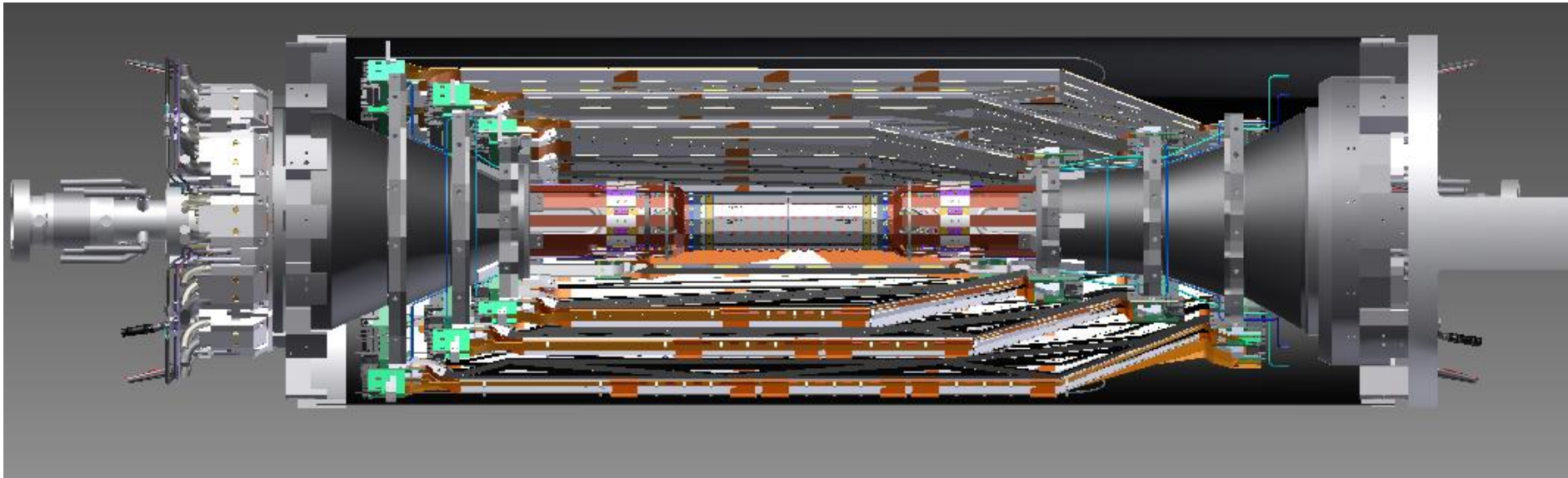
- 2010 Jul. VXD design snapshot
  - Bellows and BPM is implemented
  - SVD ladder design
  - PXD first design
    - With IP straight section design



- 2010Nov: (7<sup>th</sup> B2GM): PXD: CO2 cooling, SVD ending design
  - IP pipe design : almost finalized
  - SVD : straight v.s. slanted
  - Installation option discussion
- 2011: Apr (8<sup>th</sup> B2GM)
  - VXD structure : FEM analysis
  - VXD Dock area and RVC are not discussed yet.



- 2013 Jul (15<sup>th</sup> B2GM)
- Start mechanical integration of each parts
  - SVD ladder mount table
  - Thermal simulation (SVD)
  - VXD assembly table
  - Installation method discussion
  - Dock space management
- 2014 Nov.
  - First VXD integrated design (SVD Rev.2.2)



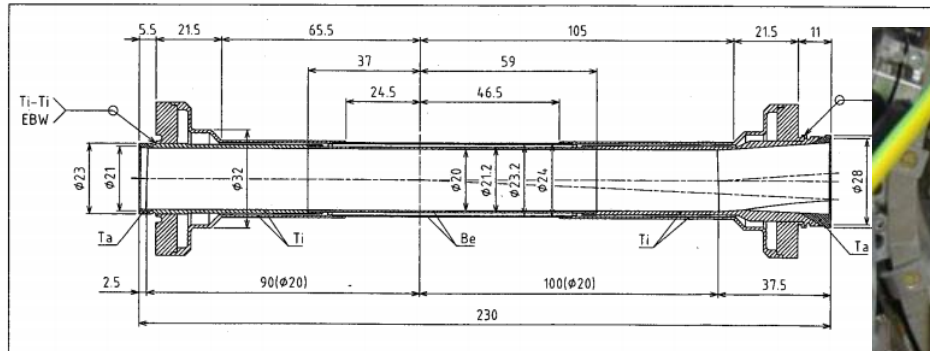
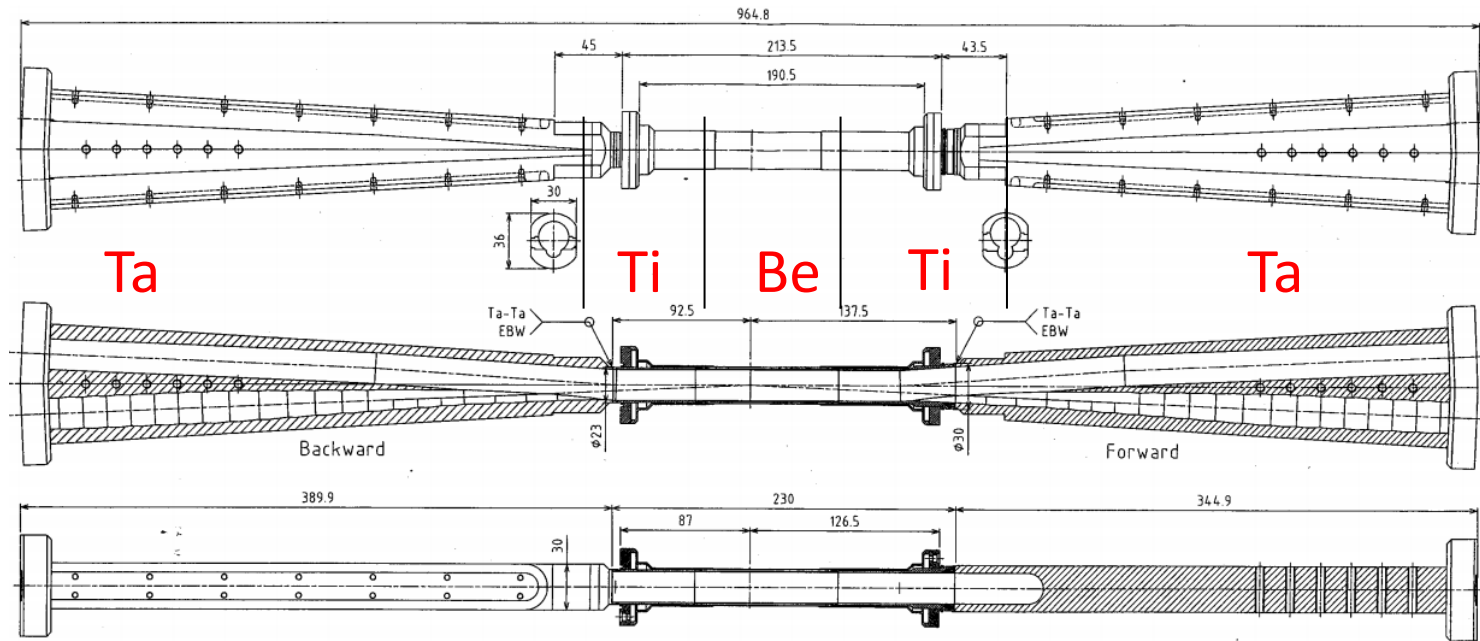
# Constraints on the IP Beam pipe design

- Heating should be controlled
  - wall current: beam induced mirror current on the BP wall.
    - Lower resistivity on the wall surface
  - Lower HOM(higher order mode) heating
    - A cavity shape in the pipe caused heating (depending on the bunch fill pattern: bunch spacing)
  - Double tube for the effective cooling (IP pipe and QCS pipes)
- SR hits on the VXD sensors should be avoided
  - Tapered ridge shape in the crotch limit the SR path
    - Secondly(characteristics) x-ray should be mitigated
- Off orbit BG (beam gas, Touscheck) should be mitigated
  - Heavy material for the crotch part
- Quite Less chemical contamination because of no Ion-pump near the IP
  - No flux on connection (vacuum brazing, EBW or HIP)
  - No oils during the milling (only N2 gas blow)
  - No chemicals on plating Gold or Copper film. (chose dry process)
- Choosing pipe material which has experience for the vacuum pipe

BP inner design : KEK vacuum group

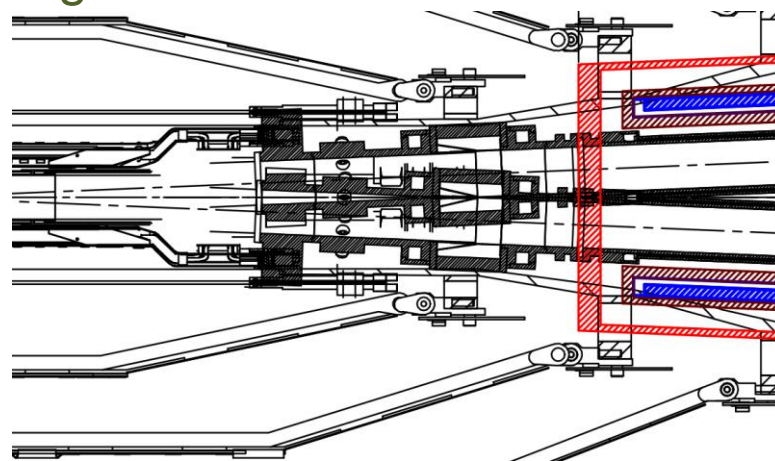
BP outer design: KEK VXD group

# Overview of beam pipe design



# How the phase3 QCS tip position was decided

- In order to avoid HOM heating each beam pipe must be separated at QCS connection point
  - Also, Space for screws and O-ring



Now IP pipe design for LS2 upgrade can not start by

0, No space for the screws and O-ring for the BP flange connection

1, no way to support the IP pipe blocking by the bellows pipe

2, no space for the BG shields at crotch to protect VXD sensors

3, no space for the ridge shape area for the SR shielding(next page)

4, no space for the BPM cable connection(key device for the collision tuning)

5, no space for the BP cooling around the QCS tip

6, Current VXD installation procedure can not adopt for the LS2 case by no RVC space

VXD support structure and cable space discussion can start after solving above issues.

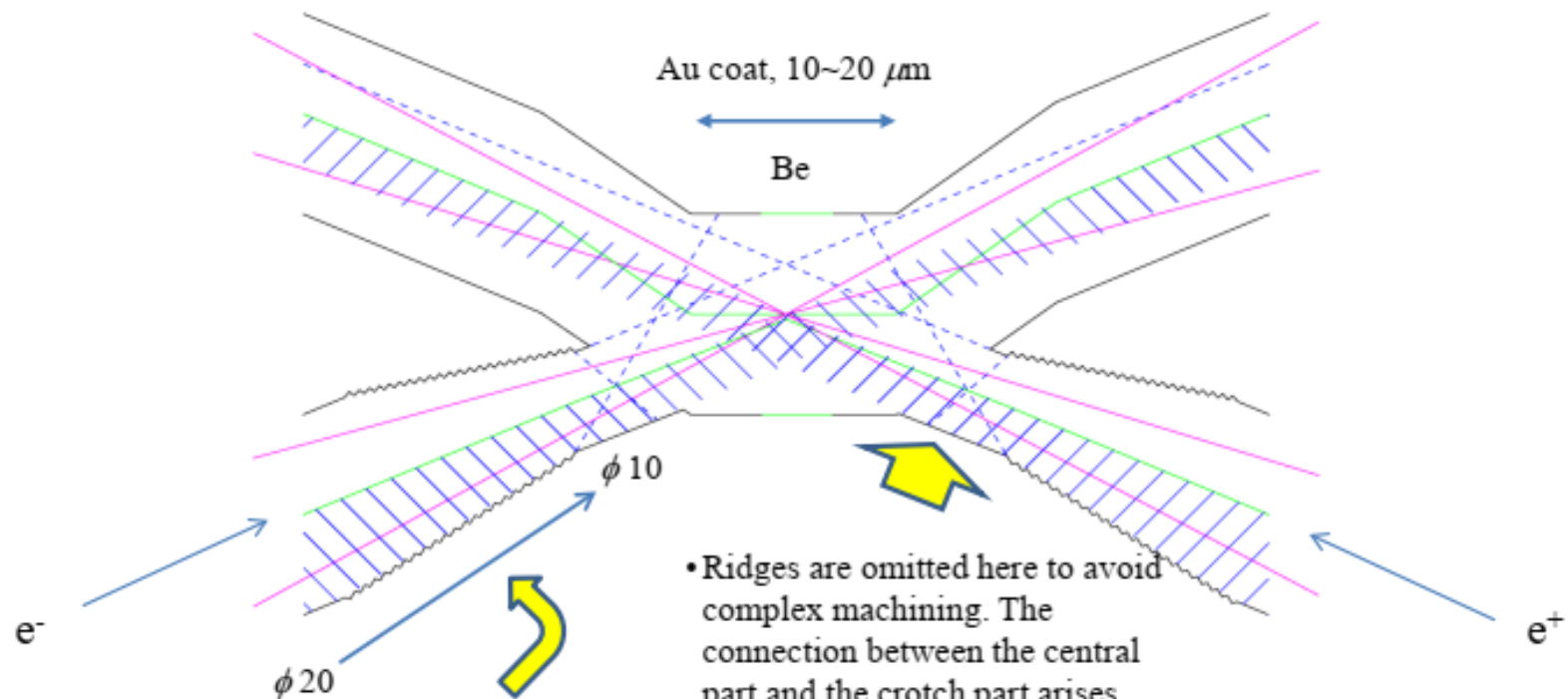
QCS beam pipe material should be Tantalum (SUS316L now)



# Another constraint

- Integration work at IR
  - IP beam pipe + bellows pipe + QCS pipe + VXD sensors
    - Quite hard of the precise integration work.
    - Current VXD was integrated on the granite table with many tools.
- For the new QCS position survey
  - Belle II detector have to be roll –out position
  - The QCS tip should be surveyed by a laser tracker
- Close communication with companies.
  - HIP,
  - vacuum brazing (brazing material and heating process)
  - EBW (parameter setting)
  - Gold sputtering
  - Milling Tantalum (5-axis NC machine)
  - Be pipe production
    - Be block (by SIP or HIP) : Materion (Brush Wellman: U.S.)
    - Milling Be block NGK (only this company have a dedicated tool in Japan)

# On Synchrotron Radiation



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

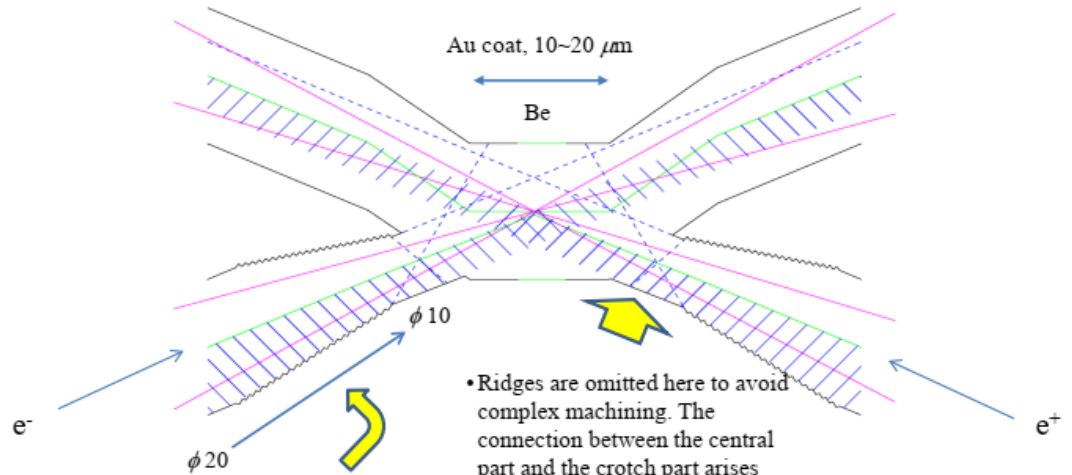
+

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

- Ridges are omitted here to avoid complex machining. The connection between the central part and the crotch part arises here.

- Instead, this part is slightly bent downward (in the drawing) to avoid the direct hit of SR from the last bend. At present, simulation shows no serious scattered photons from this part.

# On Synchrotron Radiation



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

+

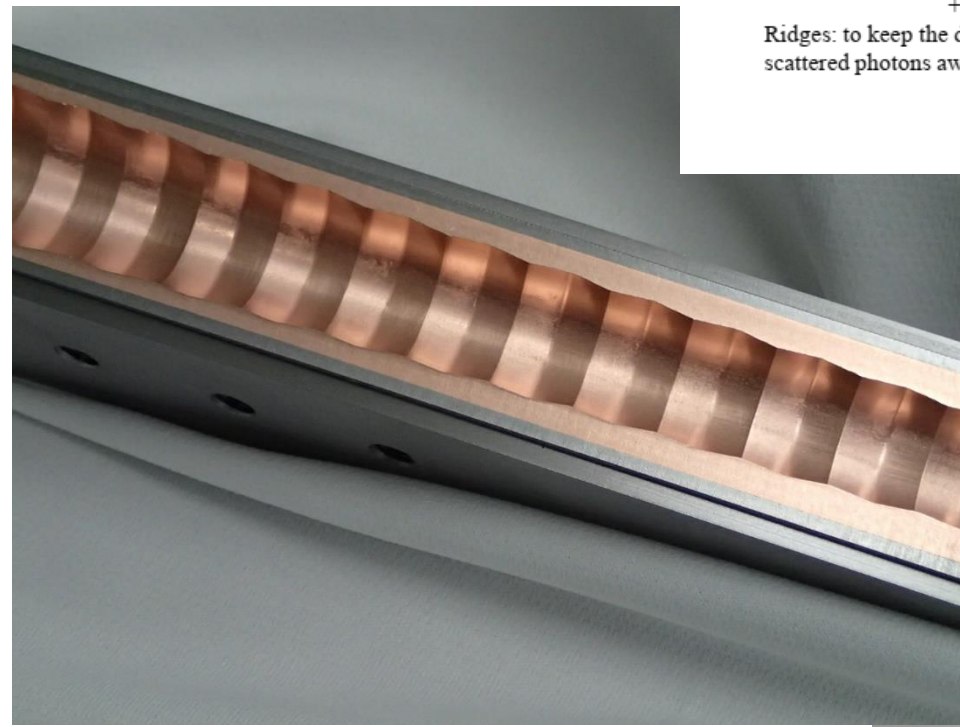
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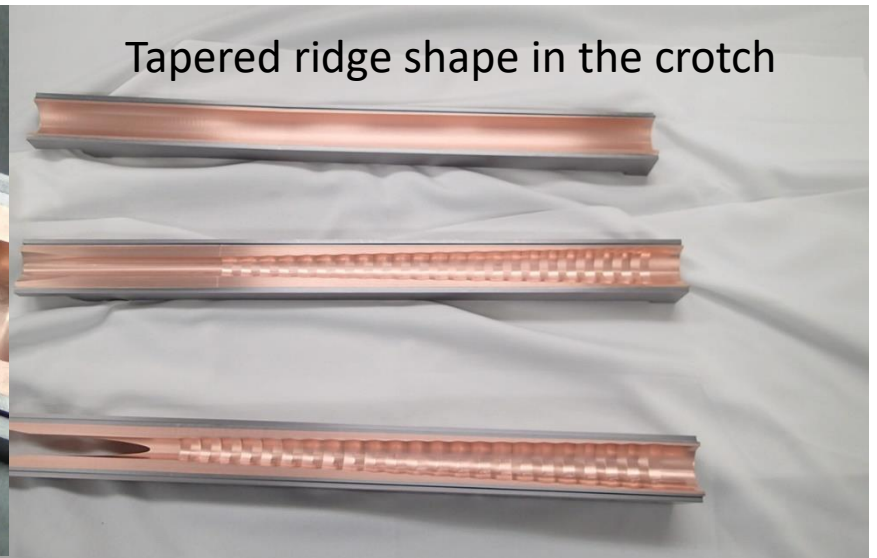
- Instead, this part is slightly bent downward (in the drawing) to avoid the direct hit of SR from the last bend. At present, simulation shows no serious scattered photons from this part.

FCC-ee MD1, 6 Feb, 2016, CERN

9



Tapered ridge shape in the crotch



# VXD design (BelleII KEK)

IF the IP beam pipe design concept was prepared,  
VXD mechanics integration concept can be discussed

1, Beam pipe + PXD connection

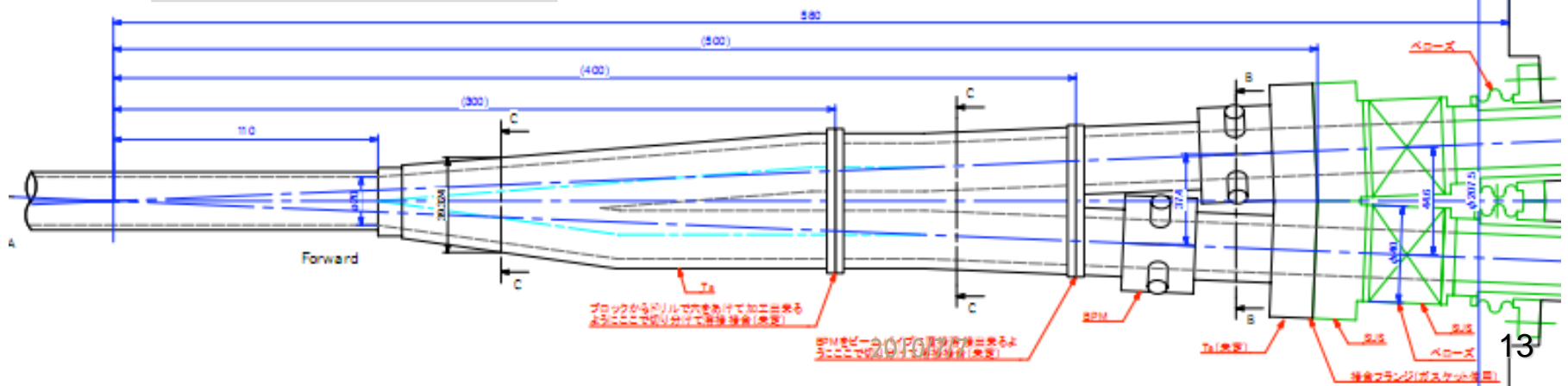
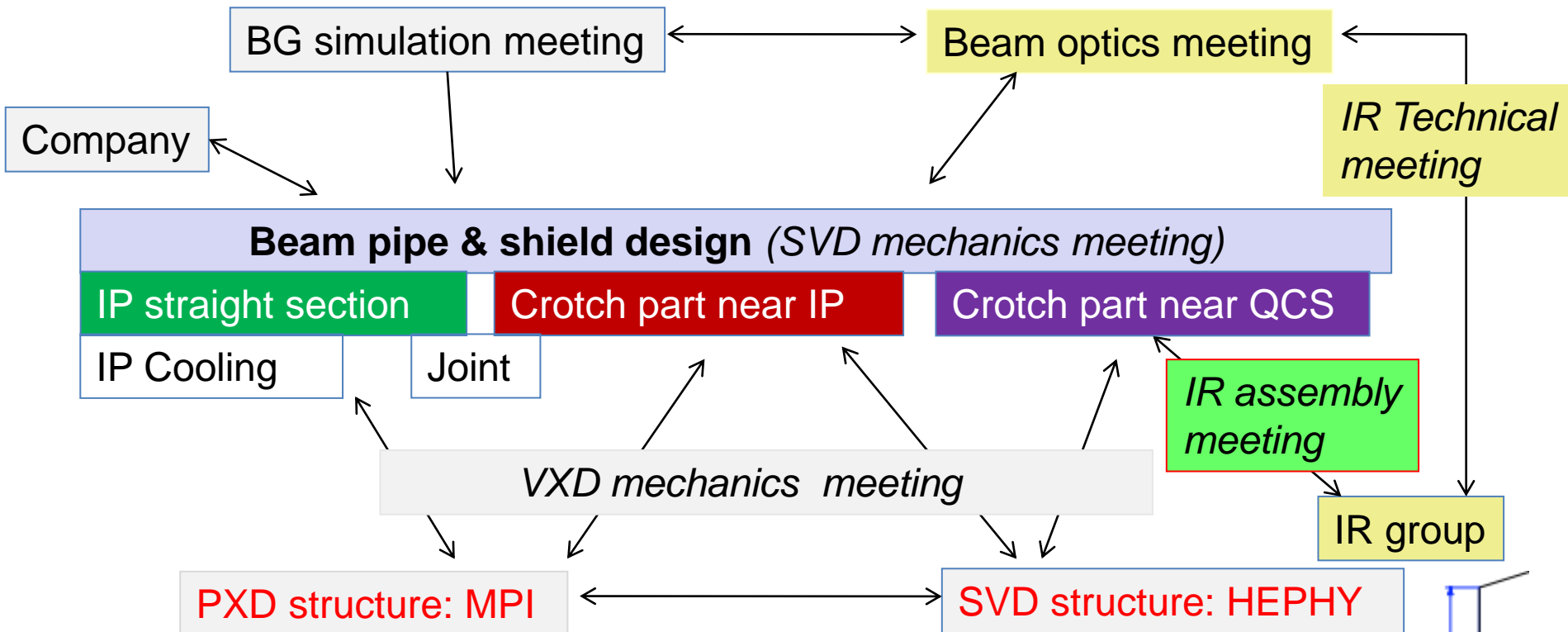
2, Beam pipe + heavy metal connection

3, Heavy metal +SVD connection

(many of iterations are necessary to reach final design)



# Interaction Region Correlation(VXD part)

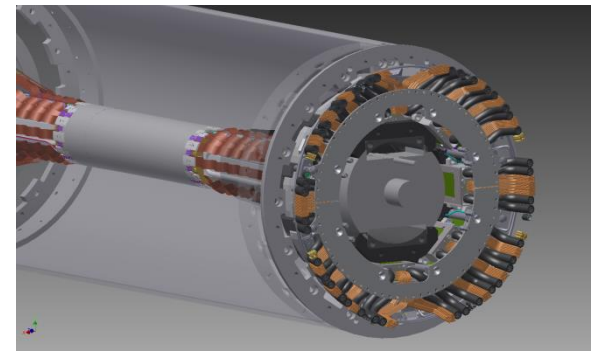
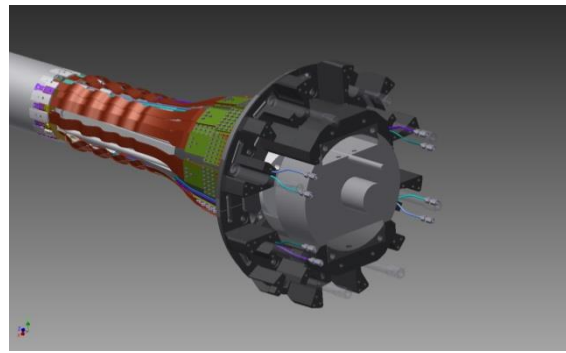
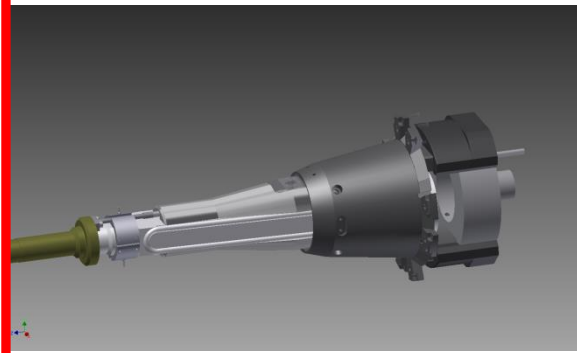
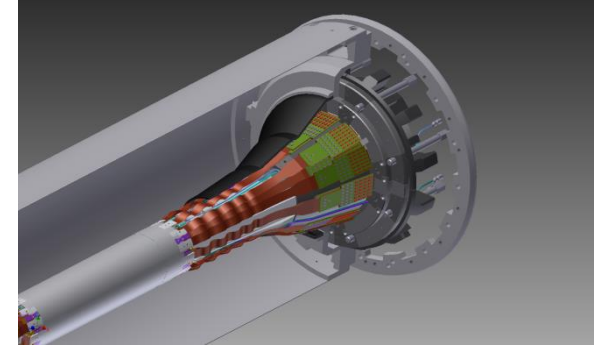
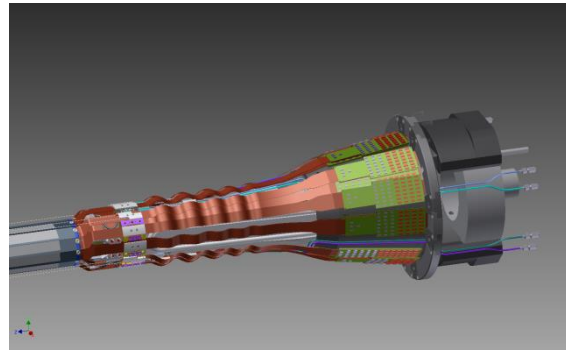
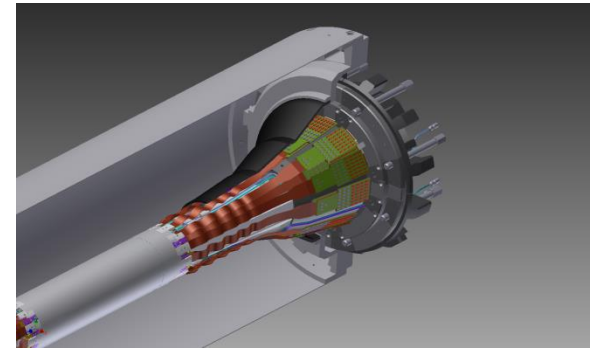
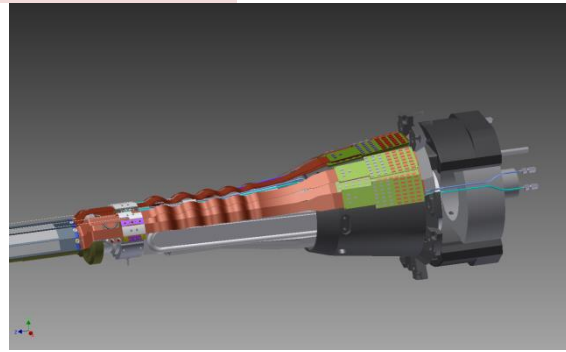
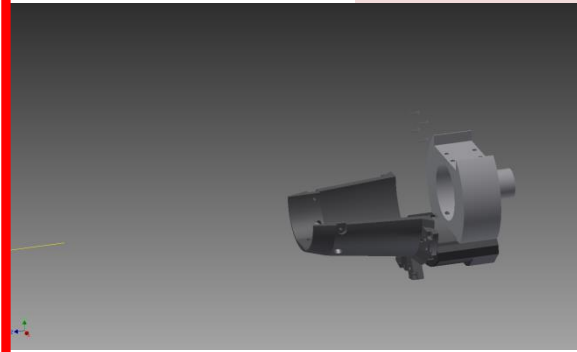


# IR integration at SuperKEKB

- **IP beam pipe:** [Kanazawa\(Vacuum\)](#), [Kohriki\(KEK\)](#), S.Tanaka ([K.Shibata](#), [S.Terui](#))
  - **VXD mechanical base design:** [Kohriki](#), [Koike](#), [Kanazawa](#) , Tanaka(KEK)
    - Heavy metal shields, Outer cover, End-flange, integration steps
  - **VXD mechanical integration:** [Kohriki](#), J.Suzuki, KEK group
  - PXD : [Tscharlie\(MPP\)](#), [C. Kiesling\(MPP\)](#) -> D.kittlinger (MPP),([K.Gadow\(DESY\)](#))
  - SVD: [Immanuel](#)-> [F.Buchsteiner\(HEPHY\)](#), [M.Friedl \(HEPHY\)](#),
  - Diamond, VXD monitors: [L. Vitale \(Trieste\)](#)
  - **VXD installation:** [Benny\(MPP\)](#)-> D.kittlinger , ([Tanaka](#))
  - VXD service design: [Tscharlie](#), [K. Gadow](#),
  - Bellows pipe: [Kanazawa](#), [K. Gadow](#)
  - RVC: [K. Gadow](#), [Kanazawa](#)
  - VXD cooling test: [H.Ye \(DESY\)](#). [R.Stever\(DESY\)](#).
- VXD mechanics group (S. Tanaka)**  
First Combined VXD design(2011-2014)  
*[Kohriki](#), [Koike\(BP, VXD srtructure\)](#),  
[Tscharlie\(PXD\)](#), [K. Gadow\(PXD,BP\)](#),  
[F.Buchsteiner\(SVD\)](#)*
- Gap sensor btw. CDC and QCS: [Kawamoto](#) (magnet group)
  - BPM@Bellows: [Tobiyama](#) (monitor group)
  - QCS: [Ohuchi](#), QCS group, ([Kanazawa](#))
  - Paraffin cooling for IP pipe: [H.Nakayama](#), ([Kohriki](#), [Tanaka](#))
  - Water cooling : [Terui](#), [Shirai](#) (vacuum group)
  - CO2 cooling: [H-G.Moser \(MPP\)](#), [S. Vogt \(MPP\)](#),[Aoki\(KEK cryogenics\)](#), [Kawai \(KEK cryogenics\)](#), [K.Gadow\(DESY\)](#)
  - BEAST sensors (CLAWS, FANG, PRUME, uTPC, He3, Pin-Diode, Plastic scintillator)
  - BG simulation group (input for the mechanics design) [H. Nakayama](#). [S. Vahsen](#)
  - **CDC:** [Kohriki](#)
  - Belle structure group : [I.Nakamura\(KEK\)](#), ([I. Adachi](#))
- Name with underscore: machine group

# VXD assembly steps proposal by KEK(2015)

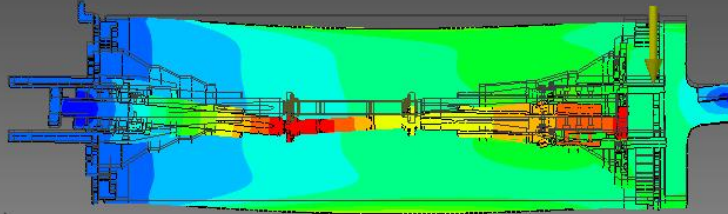
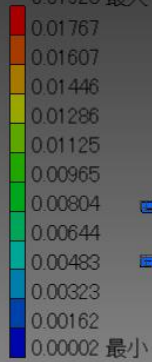
BP+HM+PXD assembly



Each step has verified individually

# Mechanical analysis

変位 (mm)  
2013/09/02 15:41:12  
0.01928 最大



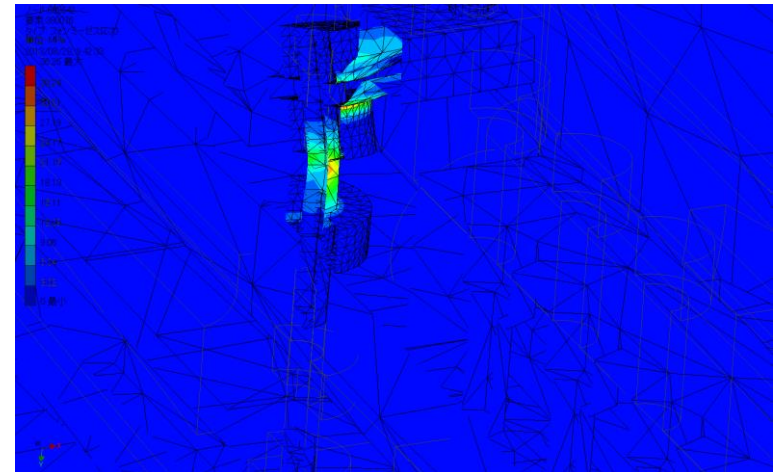
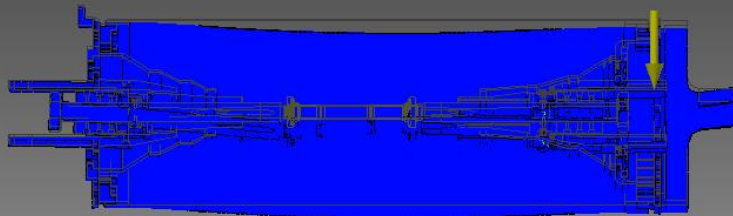
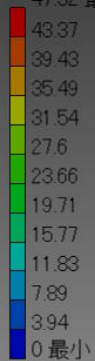
Backward point fixed

Deformation : MAX19.3 $\mu$ m

FEM analysis on VXD installed position

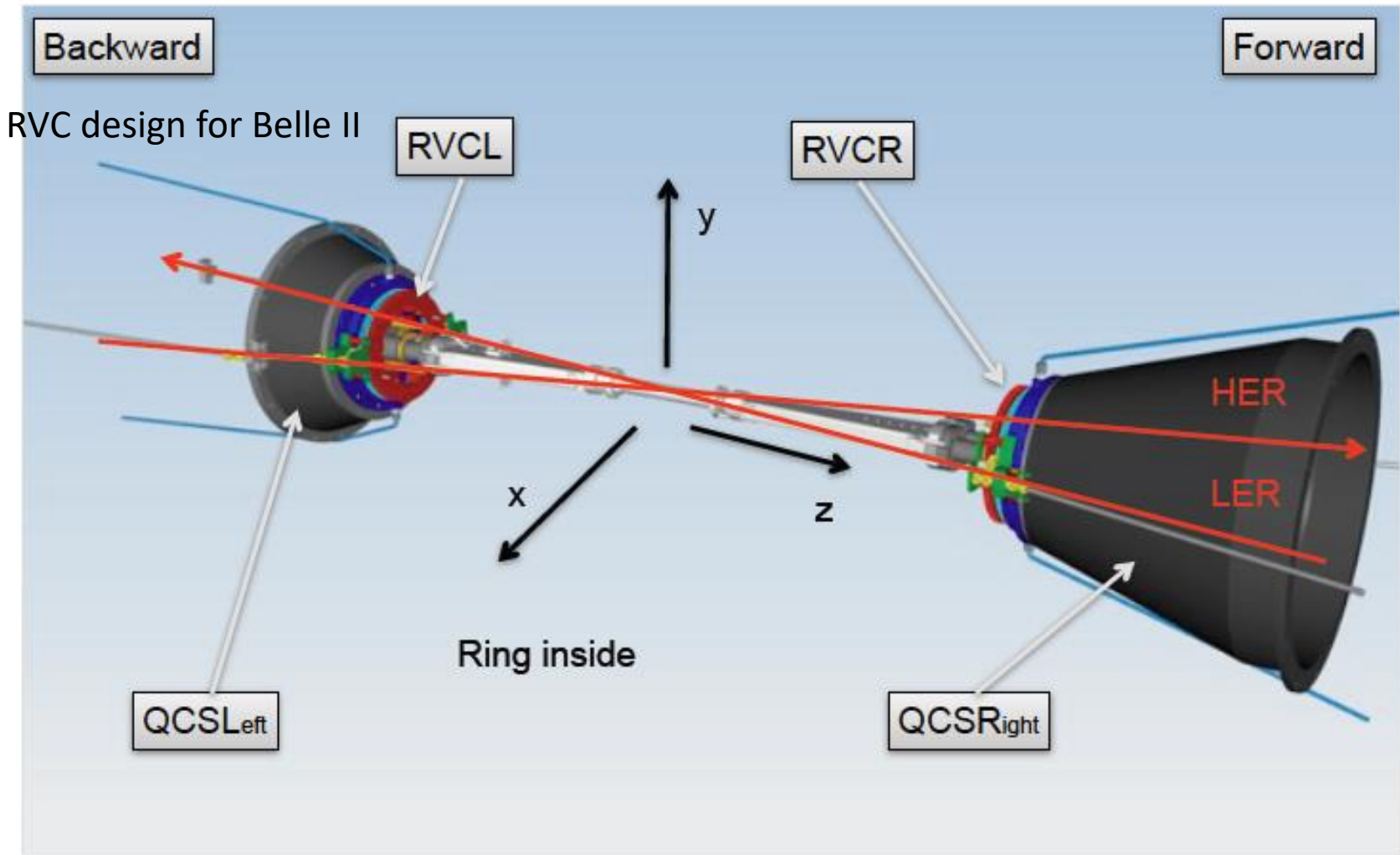
Installed position

タイプ フォンミーゼス応力  
単位: MPa  
2013/09/02 15:42:50  
47.32 最大



equivalent stress : MAX47MPa

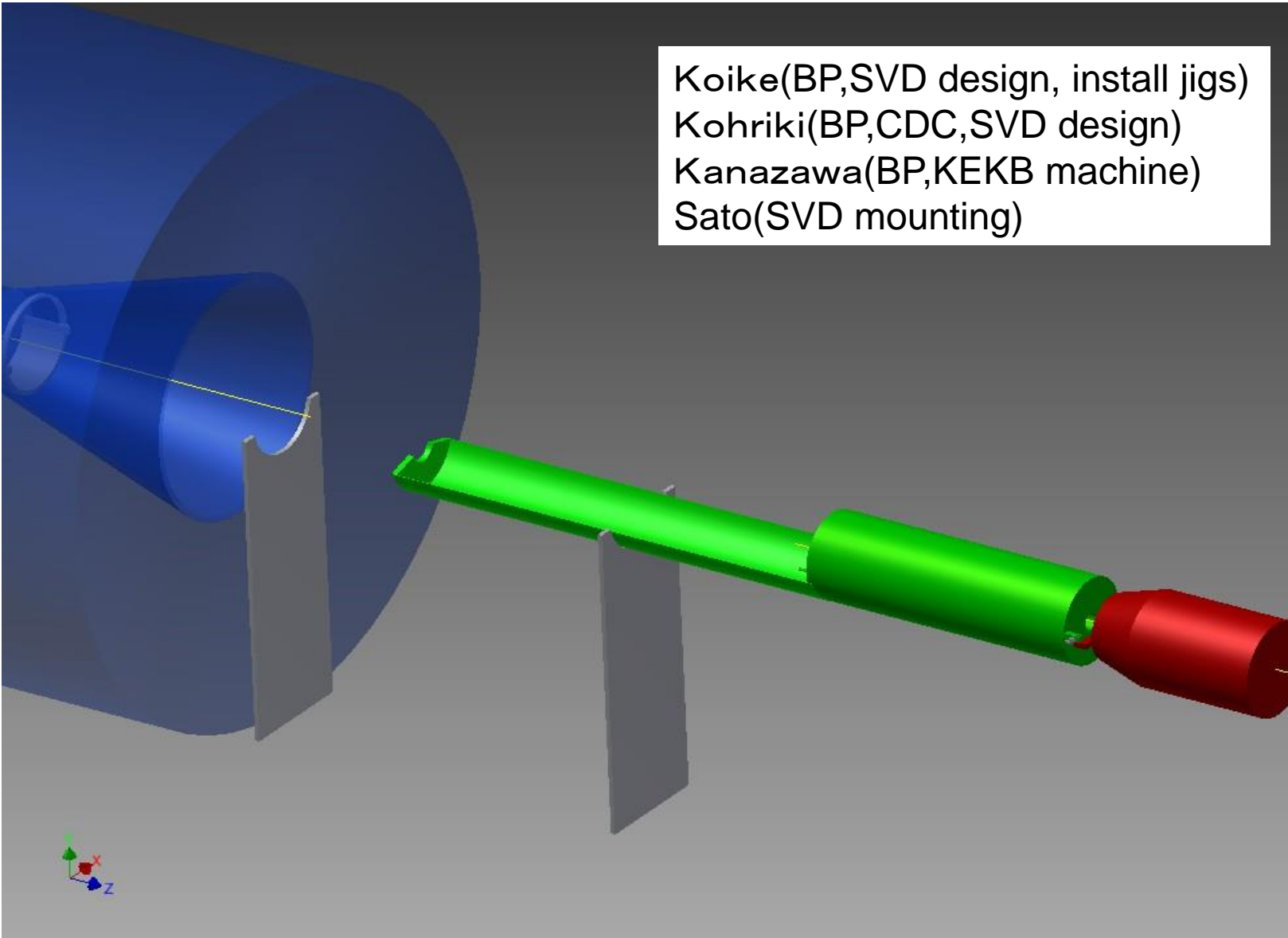




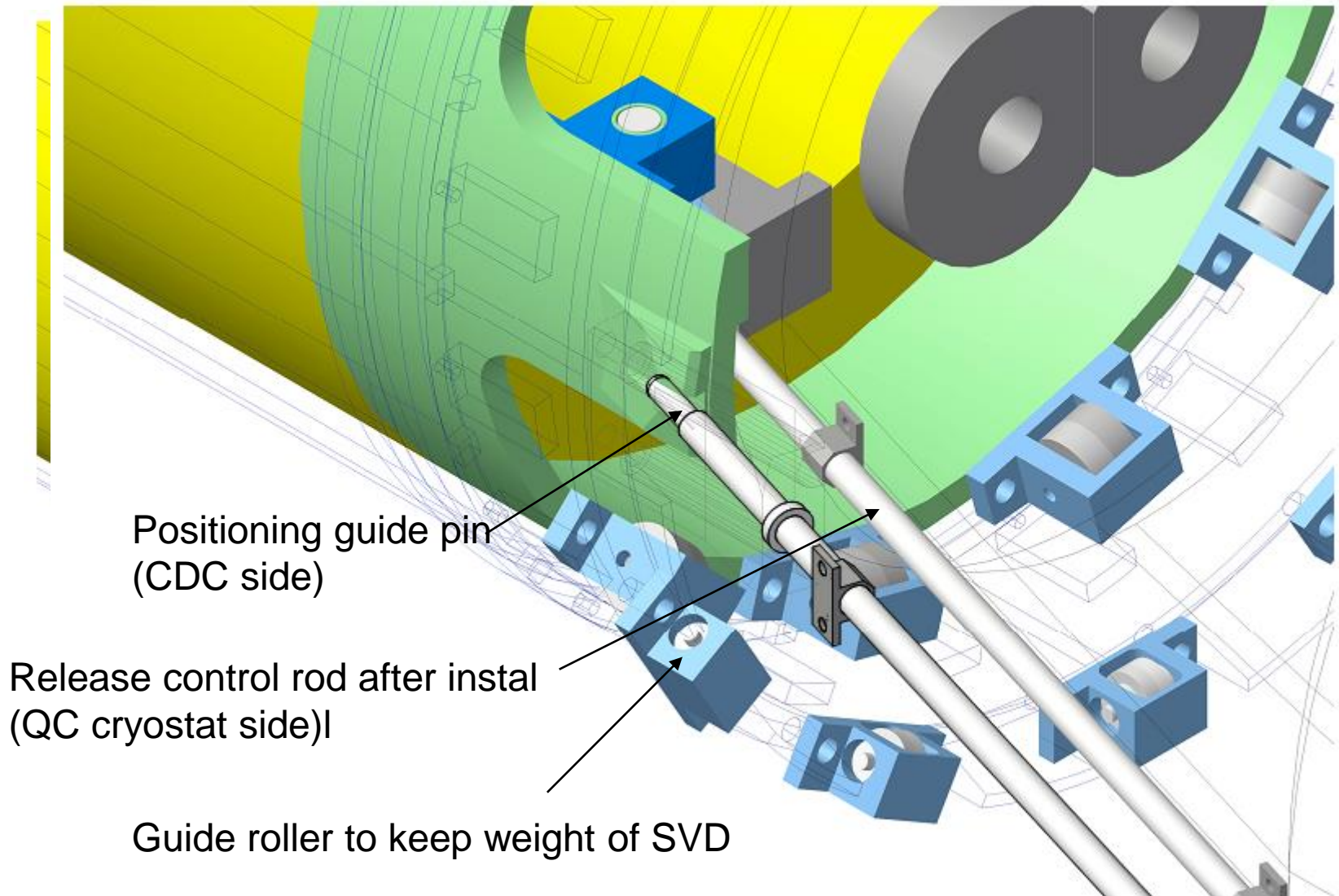
RVC meeting in Apr. at KEK (K.Gadow, K.Kanazawa)  
RVC design is almost agreed (screw hole issue)

# Vertex detector installation(Old option)

Koike(BP,SVD design, install jigs)  
Kohriki(BP,CDC,SVD design)  
Kanazawa(BP,KEKB machine)  
Sato(SVD mounting)

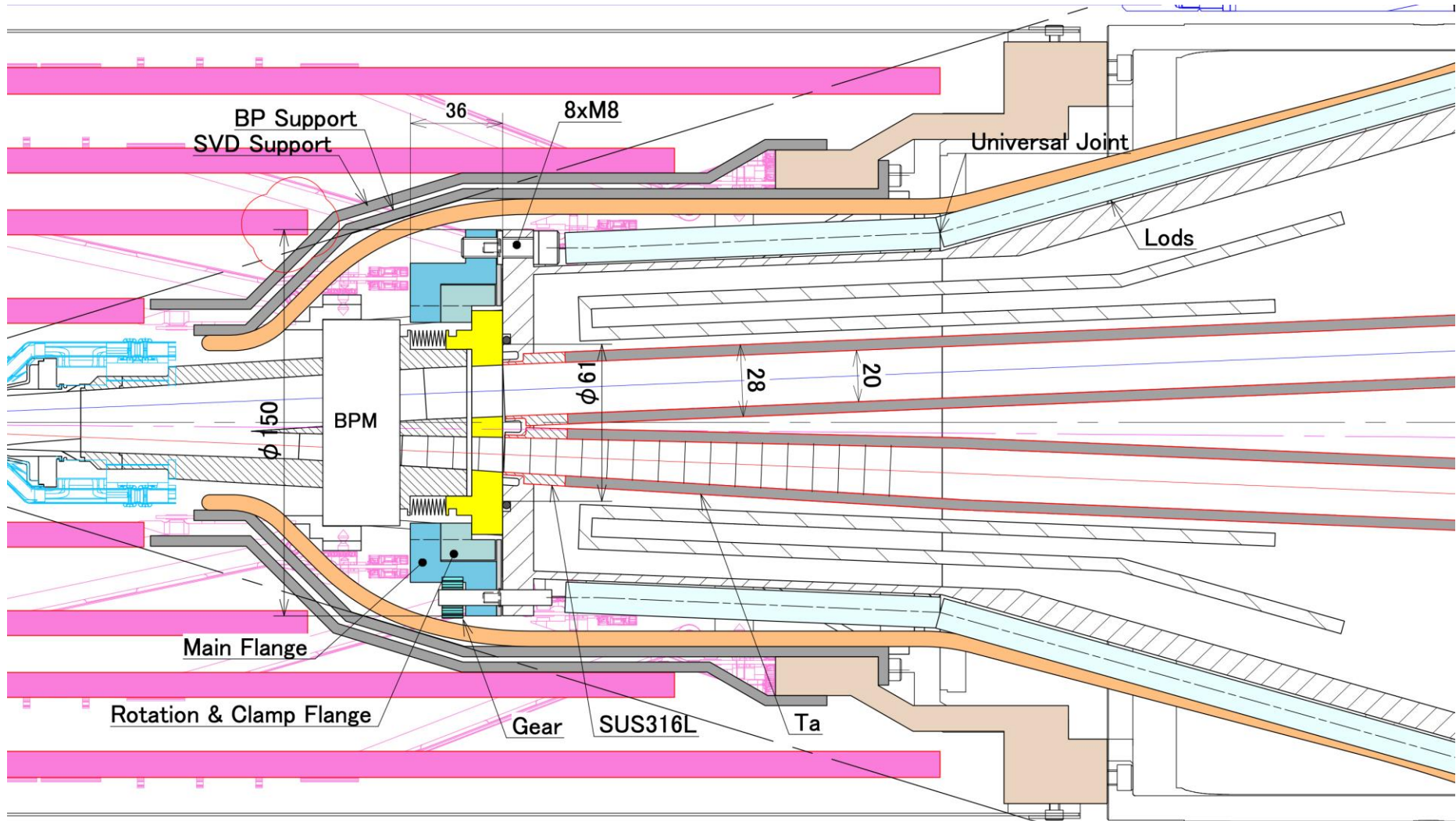


# VXD installation (mechanics)



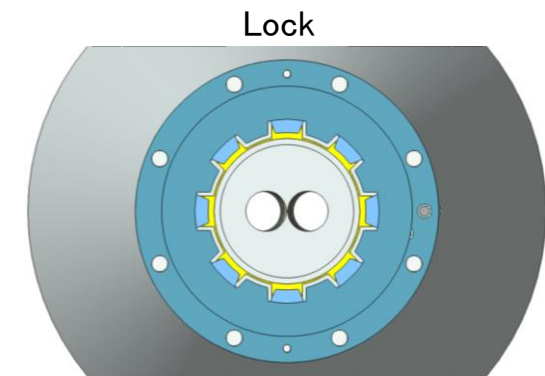
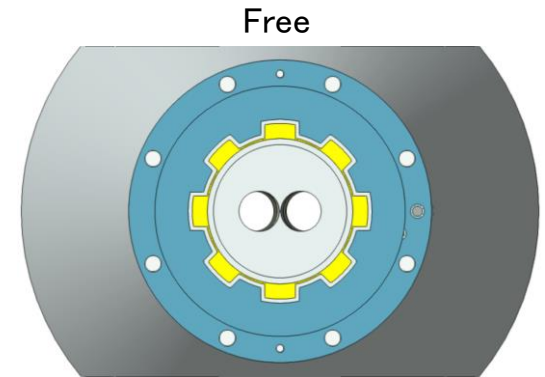
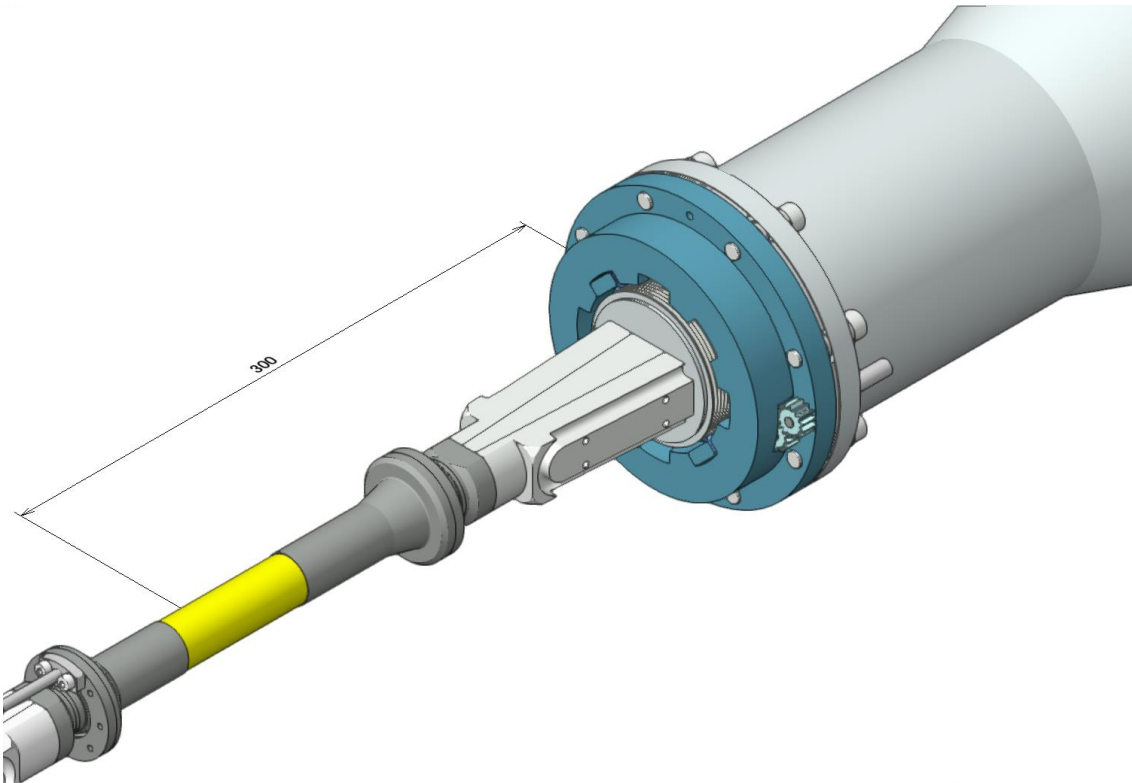
# LS-2に向けての勝手な私案

- 手動ネジ締め型RVC
- 入射側を細く出来ればCryostat先端の干渉は無くなる？
- Beam PipeがWarm BoreならCryostatに溶接出来る？ (Conceptual Idea by Kohriki)
- Beam PipeのSupportはシールドを兼ねてTa製？
- SVDのSupport Cornもシールドを兼ねてTa製？



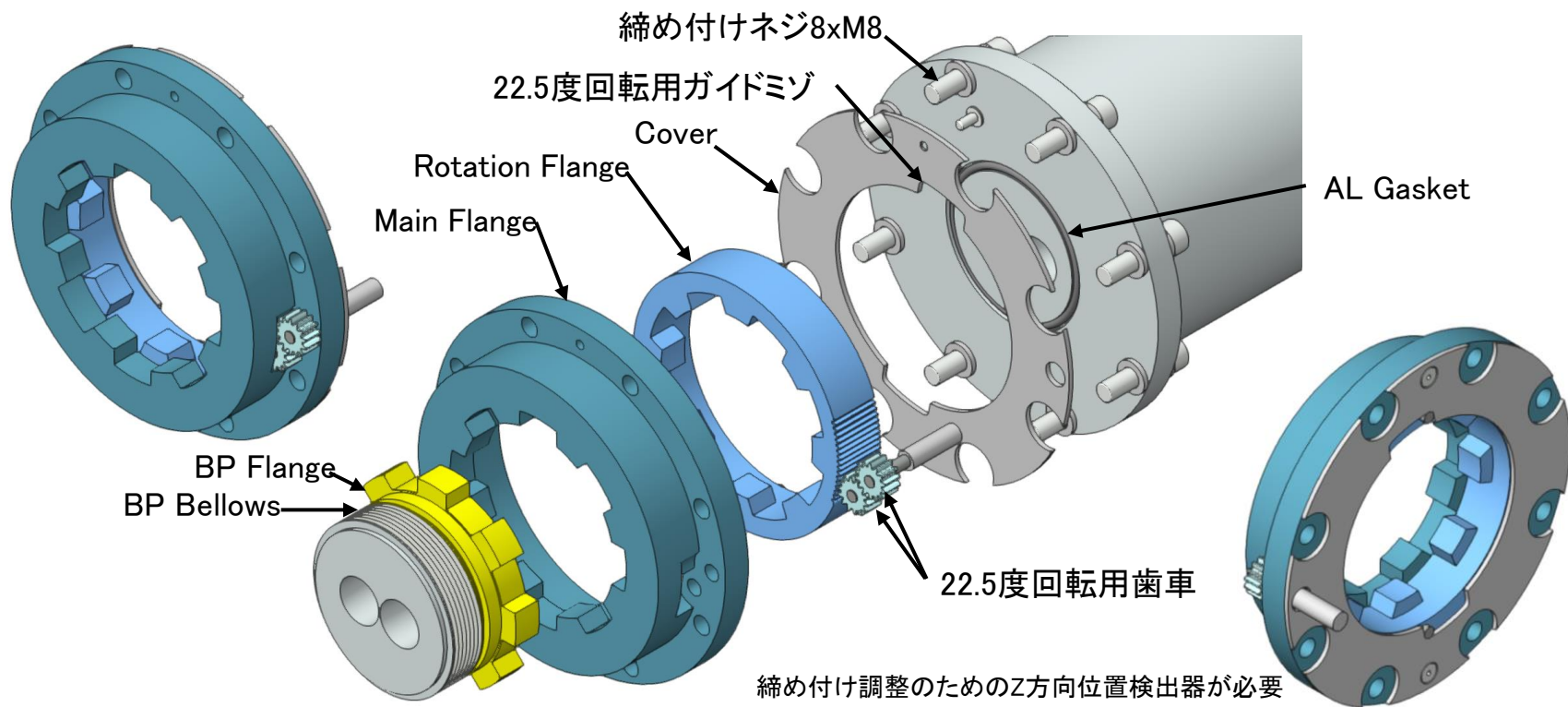
# LS-2に向けての勝手な私案

## 手動ネジ締め型RVC



# LS-2に向けての勝手な私案 (Conceptual Idea by Kohriki)

## 手動ネジ締め型RVC



# My last slide ( not summary)

- There is many points should be discussed before starting IR design
  - VXD integration
    - IP pipe + BPM + Bellows pipe + VXD + CDC and more
  - VXD shielding
  - SR management
  - Heating control
  - VXD installation
  - Beam pipe connection(IP pipe + bellows pipe + QCSpine)
  - IP beam pipe alignment
- On KEK side, there is no VXD design expert with full-time.
  - Trying to prepare the reference information of IP beam pipe
    - We are thinking of organizing a discussion group for the IR integration (from each sub-group)
  - Company's supports for the beam pipe production are no problem (we keeps good contacts).