SuperKEKB Vacuum System

- for the positron ring -

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- Outline
- Design and production status of key components
  - Beam pipes for arc section
  - Beam pipes for wiggler section
  - Pumps
  - Bellows chambers, Gate valves
- Approximate costs
- Summary

SuperKEKB

- SuperKEKB is an electron-positron double ring collider in Tsukuba, Japan.
  - Electron ring (HER; High Energy Ring): 7 GeV
  - Positron ring (LER; Low Energy Ring): 4 GeV
  - Circumference: 3016 m
- Main features
  - Goal luminosity:
    8×10^{35} cm^{-2}s^{-1}
  - High beam current;
    - LER: 3.6 A, HER: 2.6 A
  - Short bunch length
    - σ_z = 5-6 mm)
  - Short bunch spacing
    - 4 ns, 2500 bunches
  - Low beam emittances
    - ε_x=3.2 – 2.4 nm
    - ε_y=13 – 8.4 pm

SuperKEKB Vacuum System

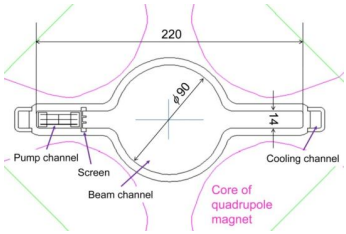
- These features make strenuous demand on the vacuum system
  - Endurance for high power synchrotron radiation (SR) from the high beam currents
  - Low beam impedance for beam pipes and the components to avoid single and multi-bunch instabilities
  - Suppression of electron cloud instability in the positron ring
  - Suppression of ion instability in the electron ring
- Very similar issues for damping rings for the damping rings of ILC.
- Here briefly reported are the designs of some key vacuum components for the SuperKEKB positron ring, and their approximate costs.

Design of SuperKEKB Vacuum System

- The designs of most of key components have been finished, and the production of them have started in full swing since last year.
- Beam pipes:
  - Beam pipes with antechambers
    - Aluminum part
    - Groove surface (in bending magnets)
    - Clearing electrode (beam pipes for arc section
    - Copper beam pipes for wiggler section
  - With countermeasures against electron cloud effects
    - TiN coating for most in wiggler magnets)
    - Solenoid (drift region)
- Pumps
  - Distributed pumping system using NEG strips
- Bellows chambers and gate valves
  - Comb-type RF shield: High HOM shielding property

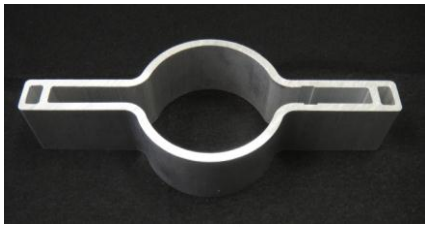
Beam pipes for arc section _1

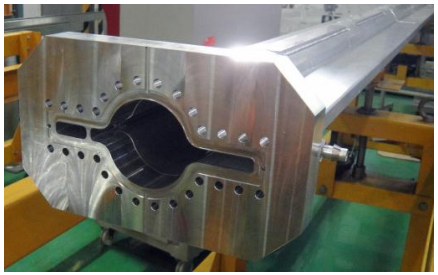
- Beam pipes with antechambers
  - Small effect of photoelectrons, low beam impedance, low SR power density at side wall
  - To be fit to the existing magnets.
  - Same cross section for flanges.

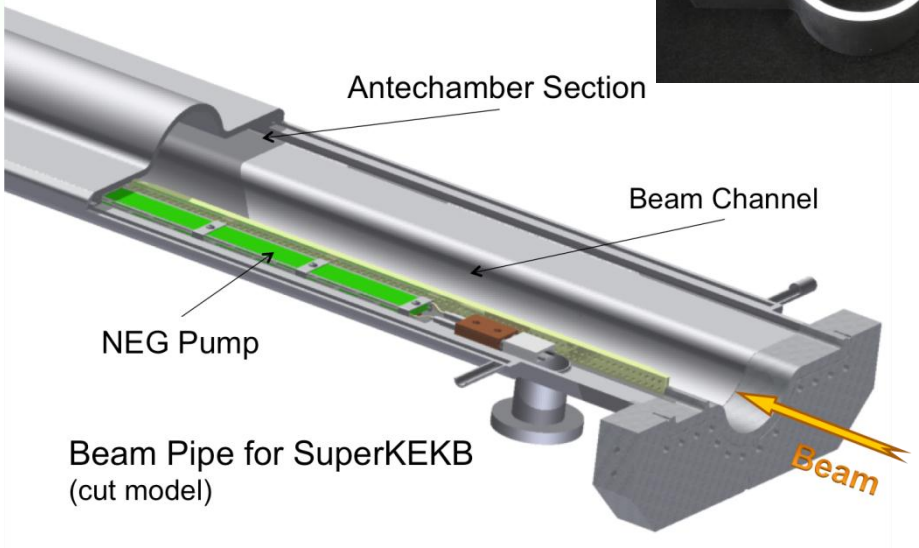


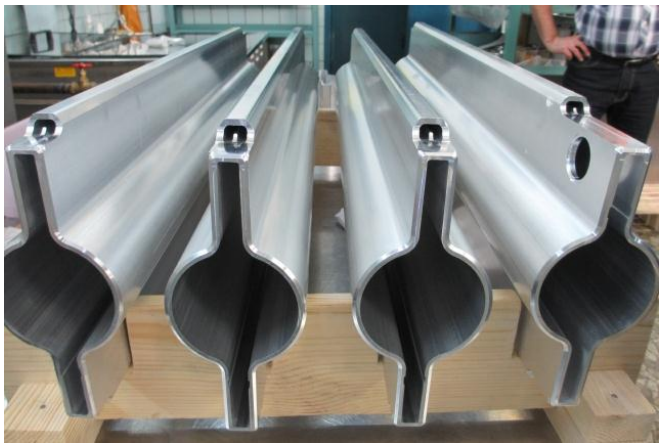
- Aluminum alloy is available for arc section
  - Extrusion method

Aluminum (A6063)

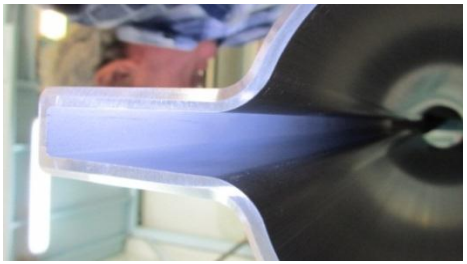




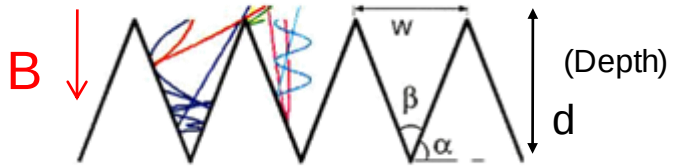




Beam pipes for arc section _2

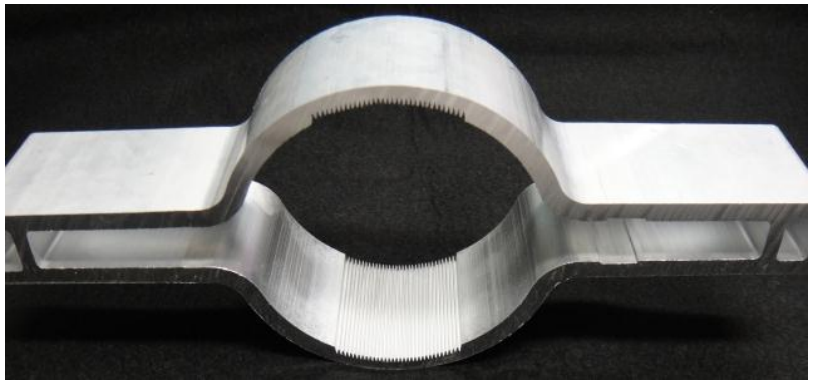


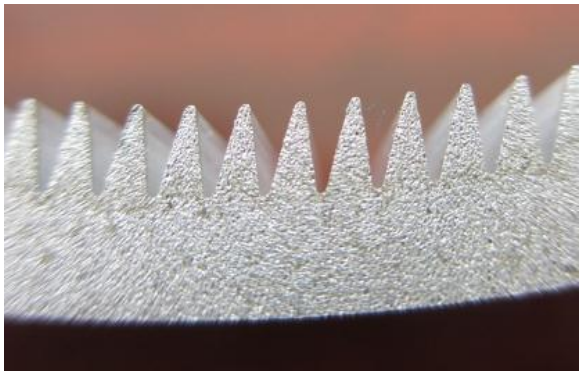
- Rough surface at the side wall
  - Suppress the photon reflection
  - Ra~20
- Grooved surface in bending magnets
  - Reduce effective SEY structurally
  - Expected reduction of electron density by factors
  - Formed by extrusion method
  - With TiN coating



by L. Wang et al.

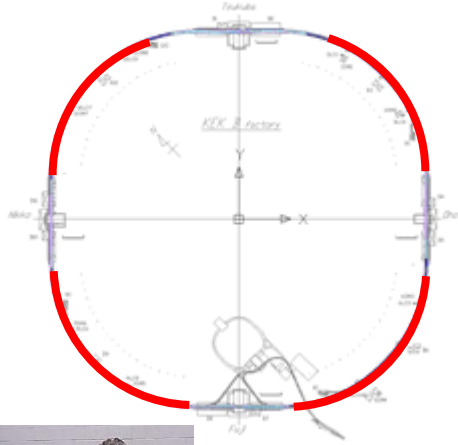
Valley : R0.1~0.12
Top : R0.15
Angle : 18~18.3°

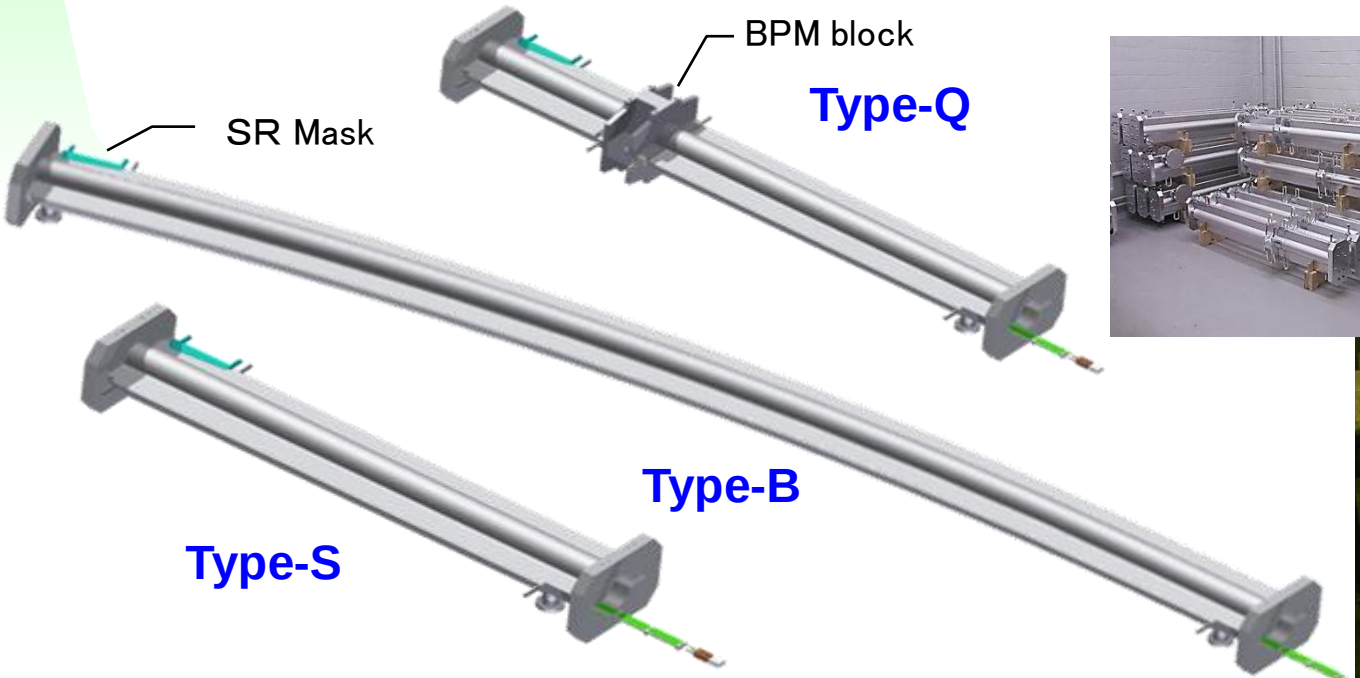




Beam pipes for arc section _3

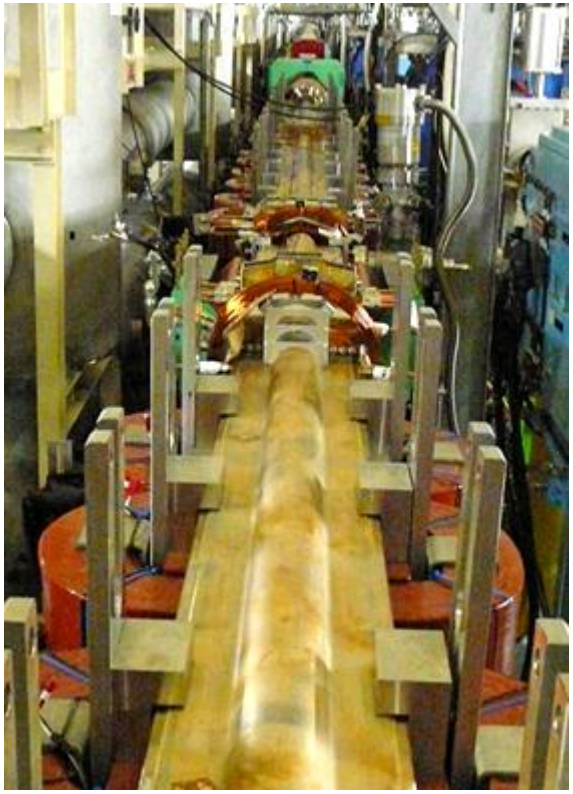
- Production
  - Formed with an extrusion method (A6063)
    - Aluminum-alloy flange (A2219)
  - Type-S, Q and B: 1861 m
  - Manufacturing is in progress.





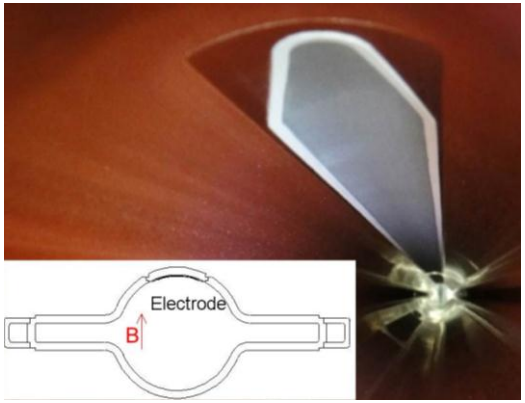
Beam pipes for wiggler section _1

- Beam pipes with antechambers
- Copper is required due to intense SR power
  - Formed by cold drawing method
  - Copper alloy flanges (CrCu)

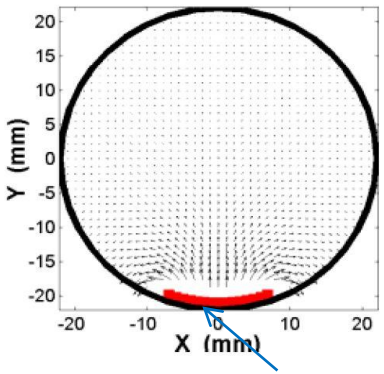


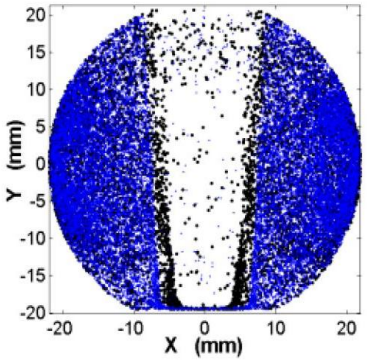
Beam pipes for wiggler section _2

- Clearing electrode in wiggler magnets
  - Attract electrons by electrostatic field
  - Very thin electrode has been developed
  - 0.1 mm tungsten on 0.2 mm Al_2O_3
  - Expected reduction in electron density around beam of ~1/100



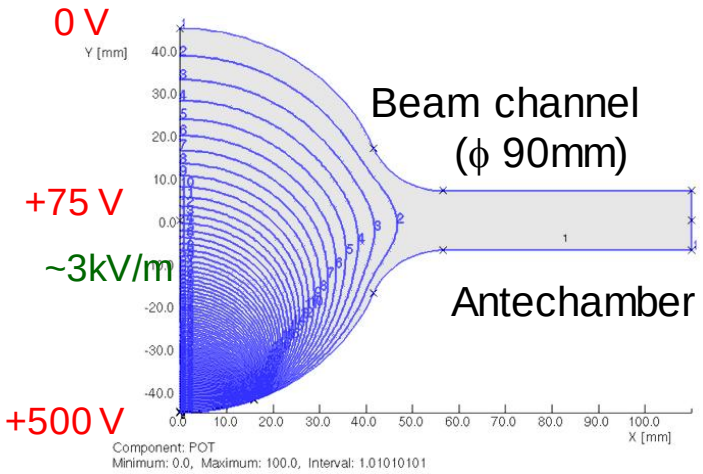
Electron density





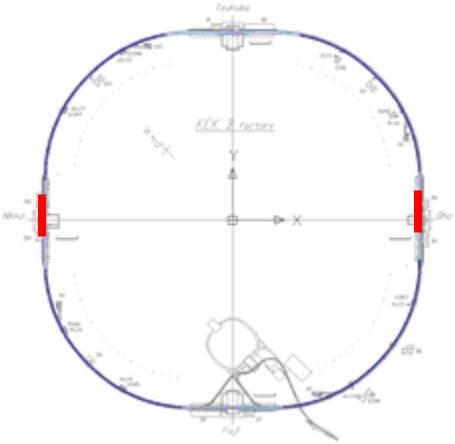
Electrode (+)

L. Wang et al, EPAC2006, p.1489



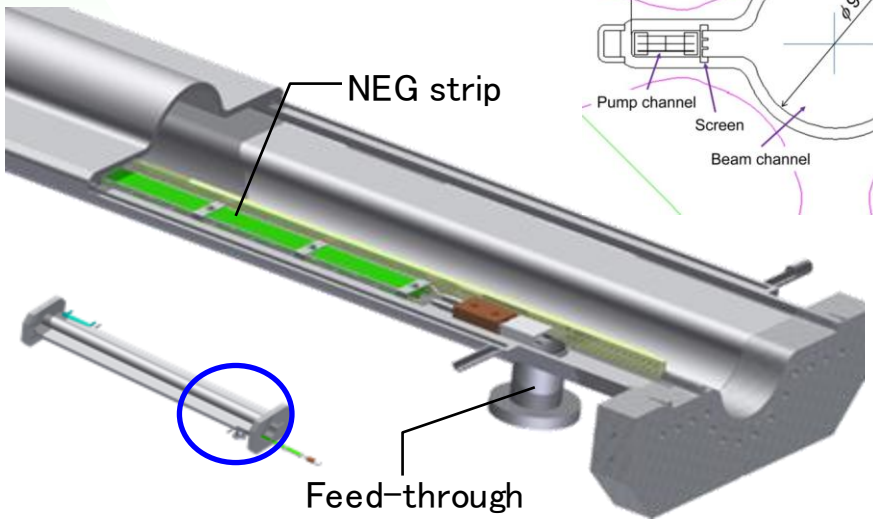
Beam pipes for wiggler section _3

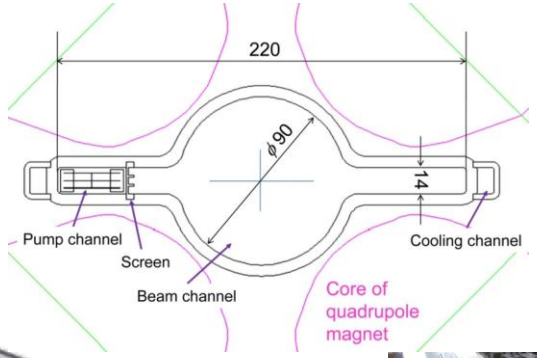
- Production
  - Nikko and Oho straight section
  - Type-S and Q 223 m
  - Type-S has two clearing electrodes.
  - Type-Q has TiN coating.
  - Beam pipes at the downstream of wiggler should be also made of copper.

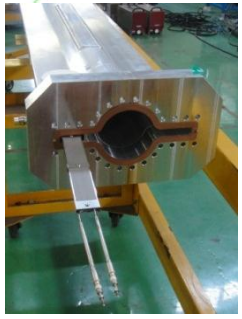


Pumps _1

- Main Pump: NEG strips
- Arc: Inserted in one of antechambers (inside of the ring)
  - Distributed pumping system
  - Effective pumping speed of ~ 80 l/s/m.
- Straight: Lumped pump ports at both antechambers
- Ion pumps: Placed every 10 m as an auxiliary pump



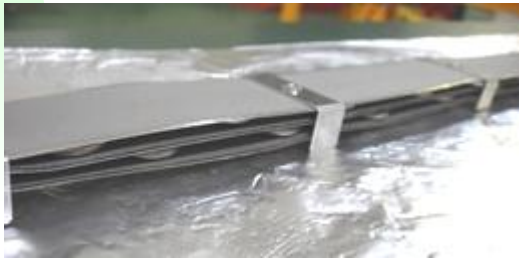


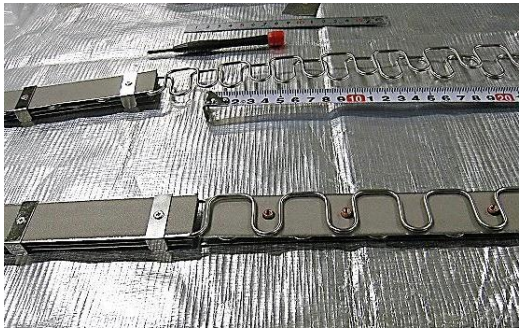


Straight Section (Wiggler)

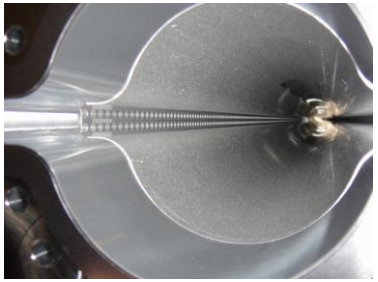
Pumps _2

- Production
  - Three layers of NEG strips “ST707 3D”
  - Activated by micro-heaters (sheath heaters)
  - Screens between pump and beam (ϕ 4 mm)
  - NEG strips (3m x 2400 pcs.), Heaters (1070 pcs.), transformer (1105 pcs.), Feed-though (950 pcs.)



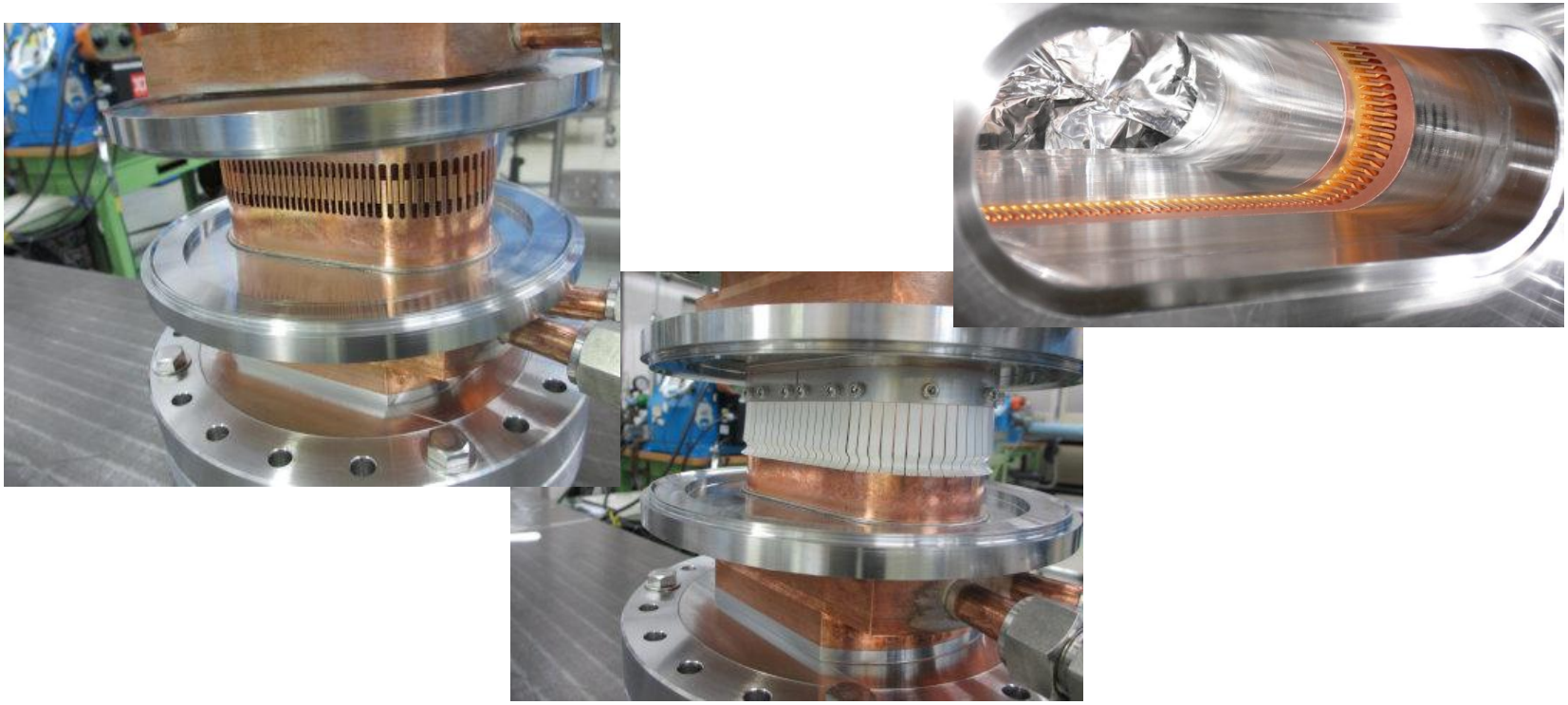


Arc Section



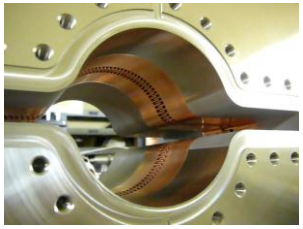
Bellows chambers and gate valves _1

- Bellows and gate valves with comb-type RF-shield
  - Sure RF shielding, thermally strong
  - Applicable to antechamber scheme
  - Finger-type for some cases, if flexibility is required.

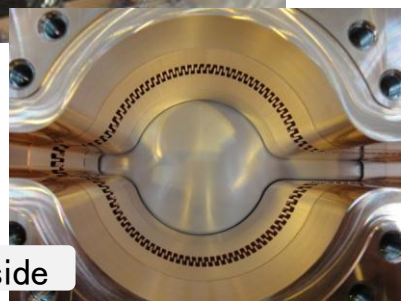


Bellows chambers and gate valves _2

- Production
- Bellows chambers
  - Aluminum alloy for arc section (690)
  - Copper for wiggler and straight section (125)
- Gate valves 24
  - Stainless steel (Ag coating)+ Comb shield (copper)



Copper bellows chamber



Inside

Aluminum alloy bellows chamber

Inside

TiN coating system _1

- TiN coating in KEK, followed by pre-baking
  - Magnetron sputtering
  - 5 sets for Q and S-types, and 2 sets for B-types
- Construction is in progress.