Upgrade Plan of KEKB Vacuum system

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- Designs for key issues
  - Beam ducts, Flanges,
  - RF-shielding, Cures for ECI,,
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Challenges for vacuum system

Key parameters for vacuum system:

- High current (LER:9.4 A, HER:4.1 A)
- Short bunch (σ_z = 3 mm)

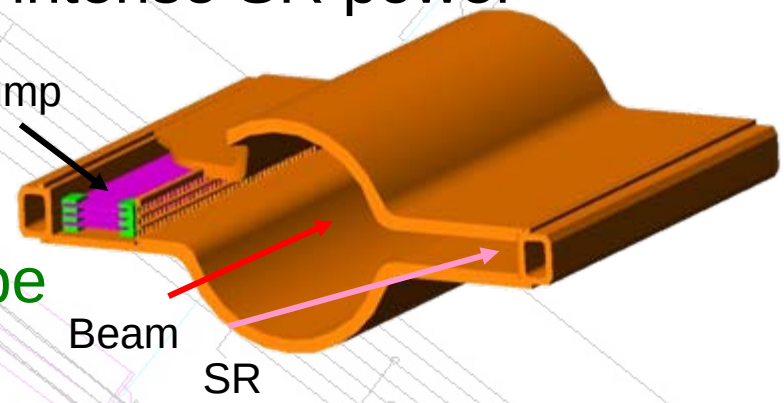
- Intense SR power
  - Max. power density of 28 kW/m (40 W/mm^2) even a half aperture of 110 mm, for example.
- High photon density
  - Photon density ~1x10^{19} photons/m/s in average
  - Large gas desorption
    - Gas load ~ 5x10^{-8} Pa m^3/s/m (for η = 1x10^{-6} molecules/photon)
    - Average pressure ~ 5x10^{-7} Pa for S ~ 0.1 m^3/s/m
  - Electron Cloud Instability (ECI) becomes a big issue in positron ring
- Intense HOM (higher order mode) power
  - For a loss factor of 1 V/pC, loss power ~ 200 kW

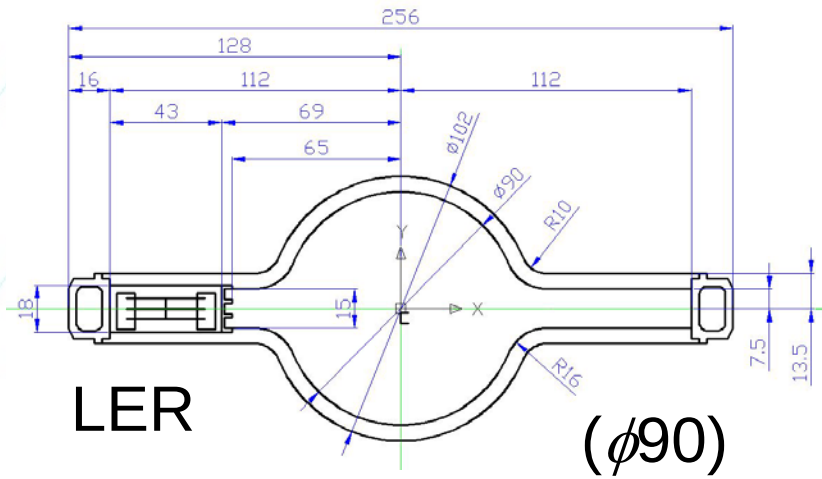
Present designs for key items

- We have been developing key components and techniques to tackle these issues.
- Beam duct
  - Copper beam duct with ante-chambers → Low SR power
    Low Impedance
    Little photoelectron
- Pumping system
  - Distributed pumping scheme → Effective pumping
- Connection flange
  - Special MO-type flange → Secure RF bridge
- RF shielding of bellows and gate-valves
  - Comb-type RF shield basically → Secure RF shield
- Movable mask (collimator)
  - Stealth type (still under study) → Low impedance
- Cures for ECI
  - TiN coating or (groove) → Low secondary electron yield
  - Clearing electrode → Direct elimination of electros

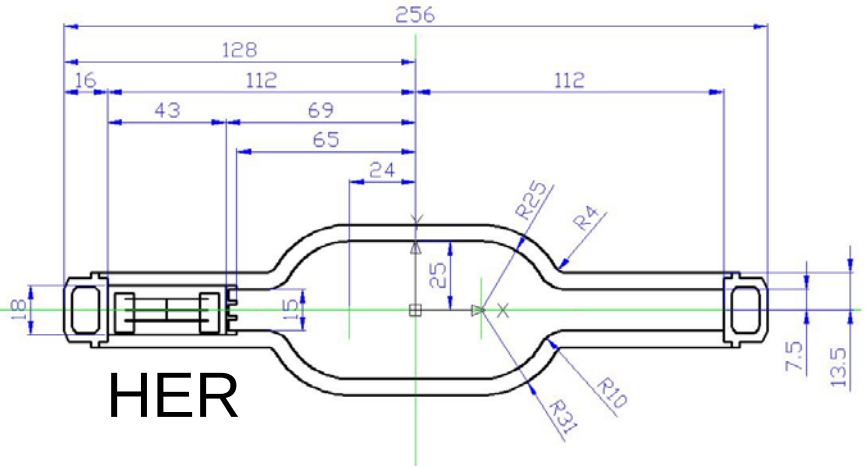
Beam duct

- Copper beam duct with ante-chambers
  - Copper is required to withstand intense SR power
- Features (compared to simple pipe):
  - Low SR power density
  - Low photoelectrons in beam pipe
  - Low beam impedance
  - Expensive





LER (ϕ90)

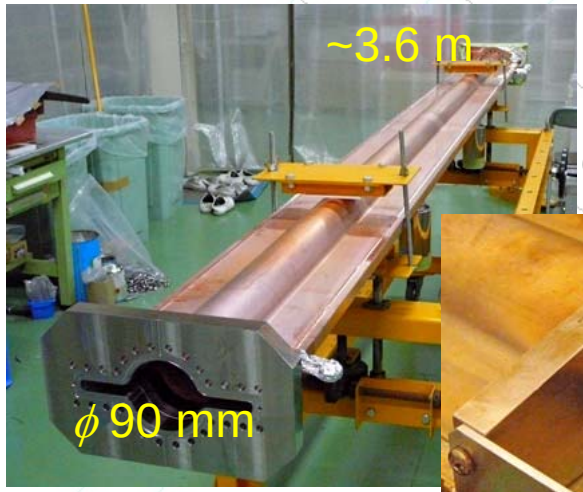


HER

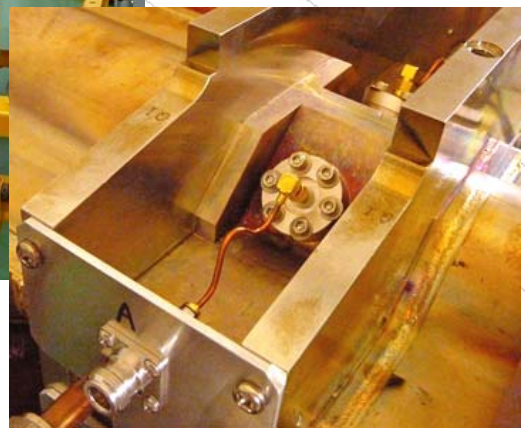
Beam duct

- Several test ducts have been installed in KEKB positron ring.
- Reduction of photoelectrons was confirmed.
- All ducts at arc section should be replaced.

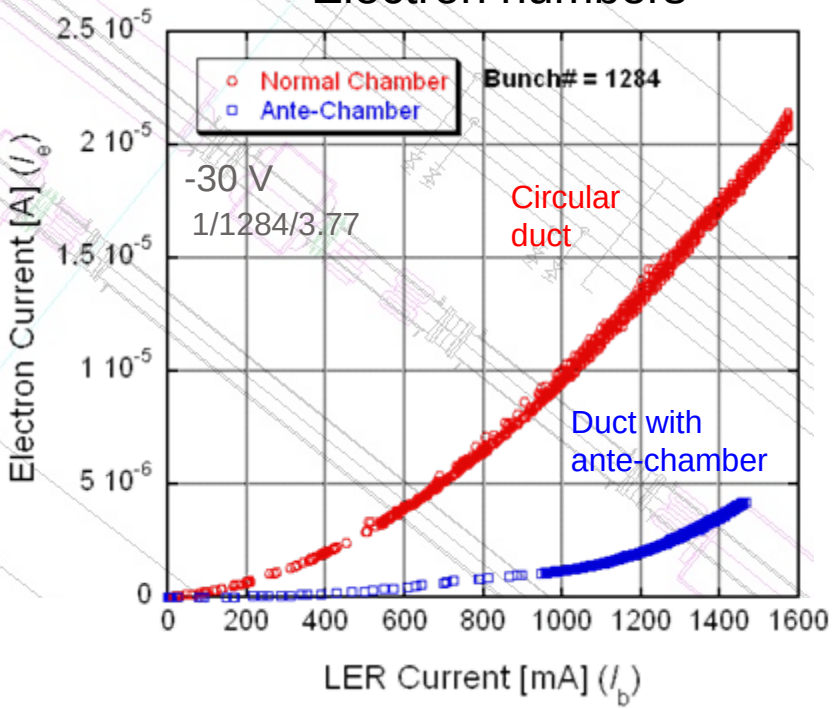
Straight duct



Q-duct with BPM



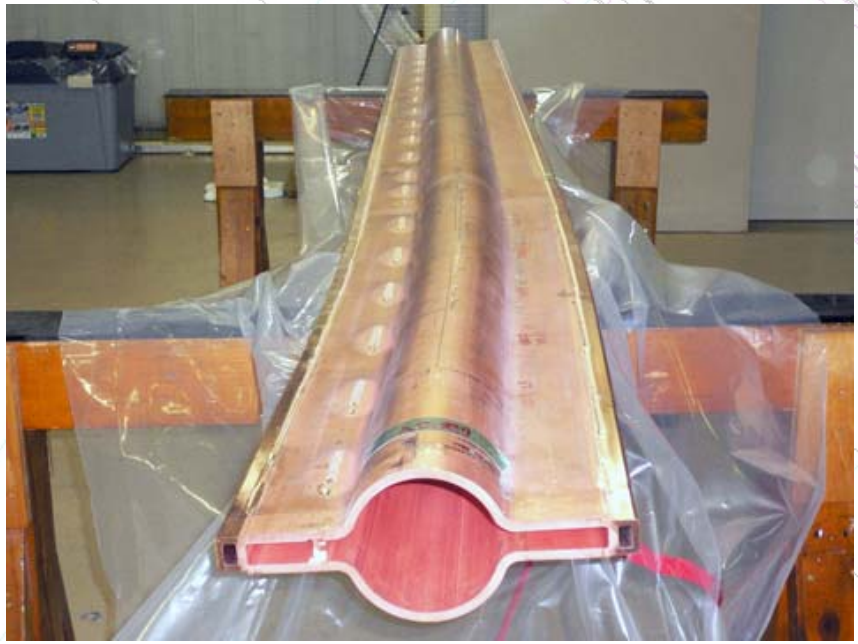
Electron numbers



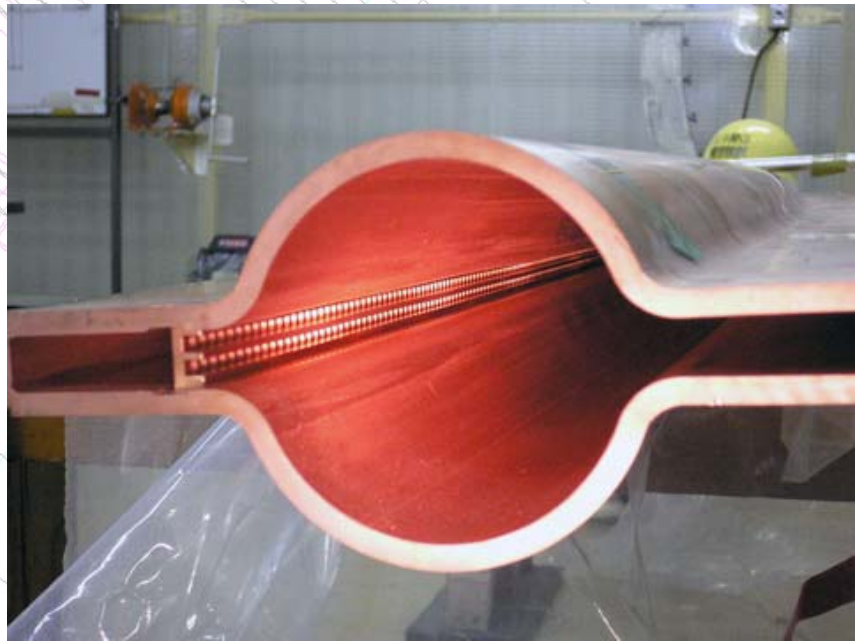
Beam duct

- Bending and installation of slits are now under study

Bent duct for LER (ϕ 90 mm)

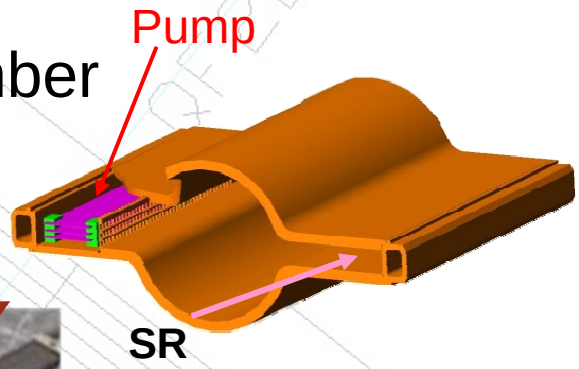


Slit for pump channel

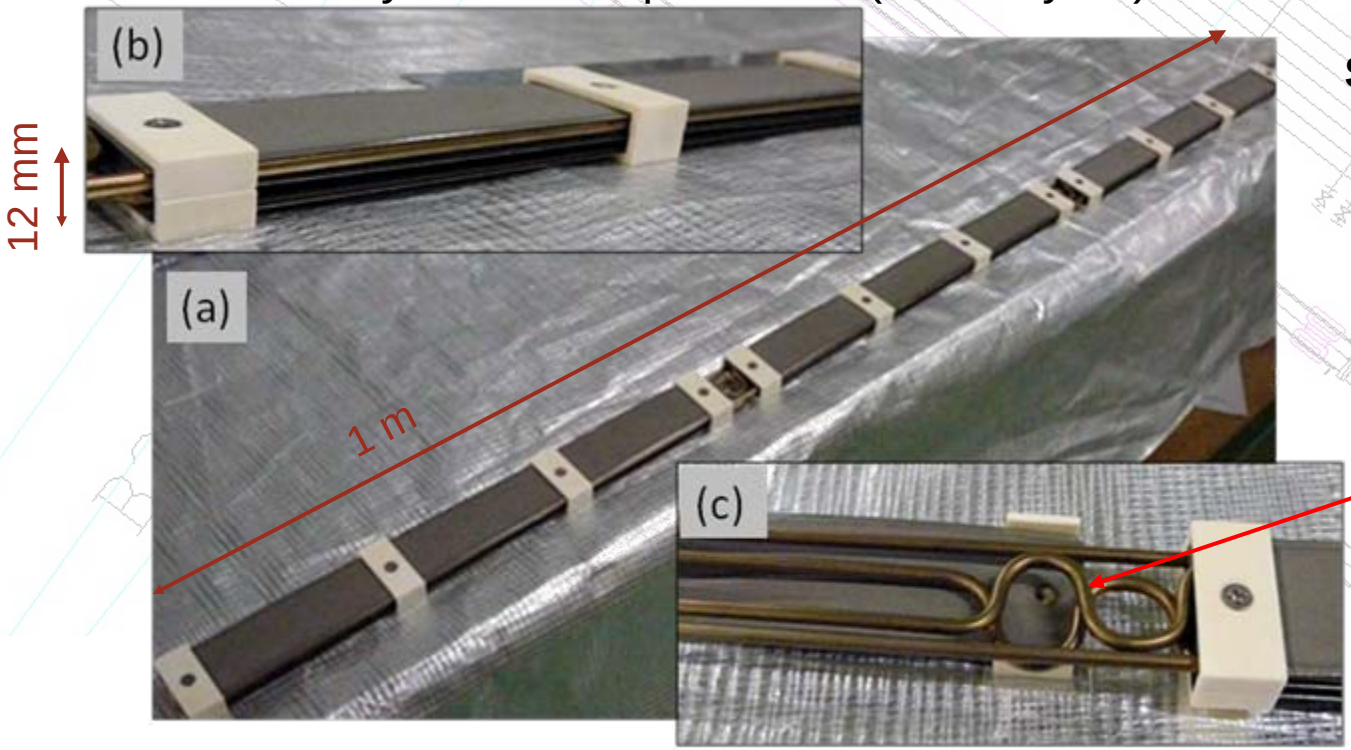


Distributed pumping system

- Multilayer NEG strips in an antechamber
  - Increase capacity and pumping speed
  - Small impedance if set in an ante-chamber
- Auxiliary pump: Sputter ion pump



Multilayer NEG strips for test (three layers)



Prot-type:
ST-707 strip
Three layers
Indirect heating

Heaters

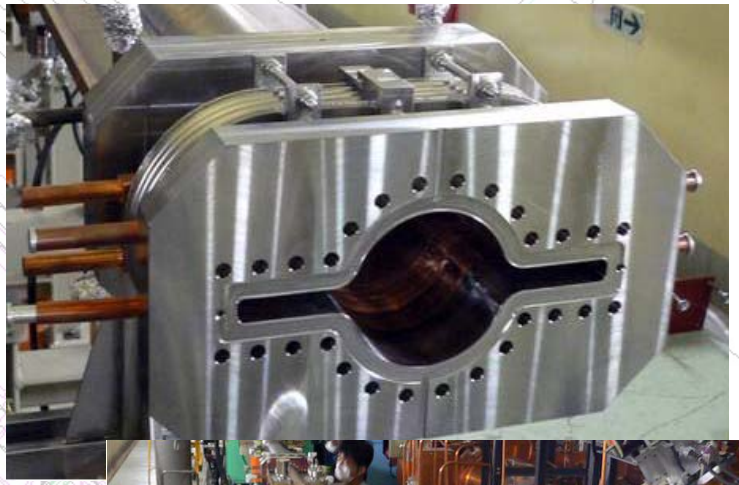
Connection flange

- Special MO-type flange for a beam duct with ante-chambers.

- Features (Compared to usual one):
  - No gap inside
  - Sure RF bridge
  - Applicable to a complex aperture
  - Simple structure

- Already applied to test beam ducts and bellows with ante-chambers.

MO-type flange for bellows



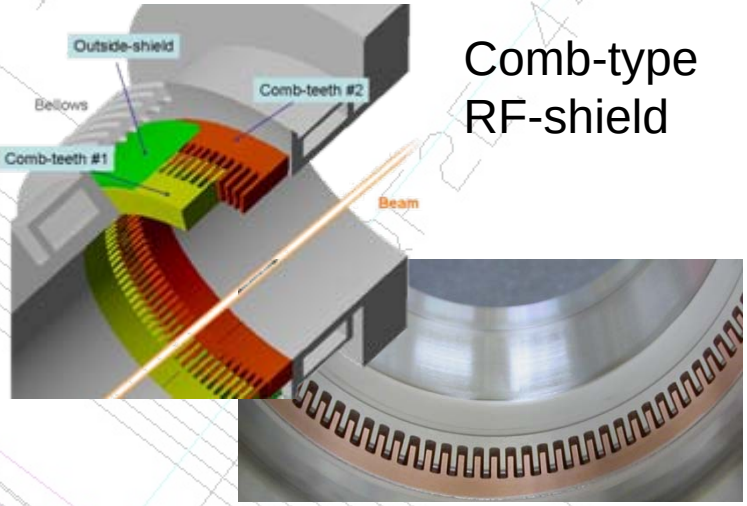
MO-type flange for beam duct

RF shielding

- Comb-type RF shield

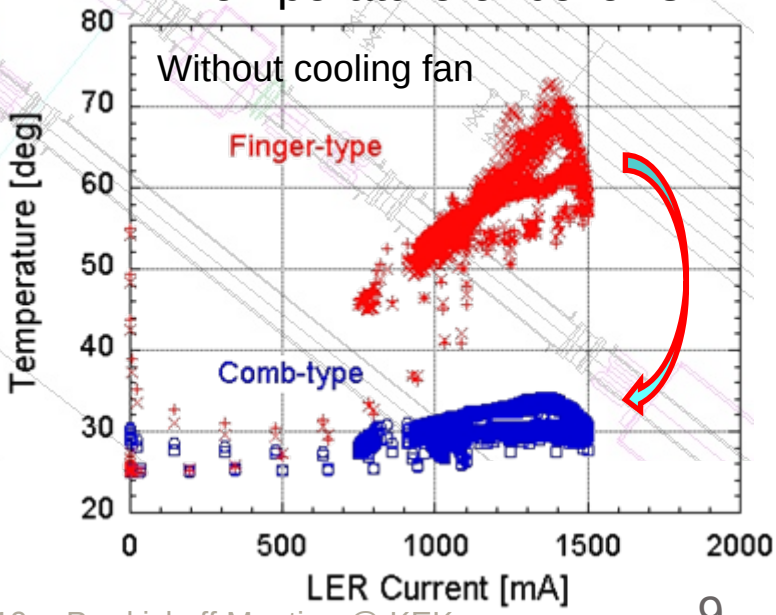
- Features (compared to finger type):
  - Low beam impedance
  - High thermal strength
  - Applicable to complex aperture
  - Little flexibility (offset)

- Effect of RF shielding was demonstrated in KEKB.
- Finger-type as an option
  - If more flexibility is required.



Comb-type RF-shield

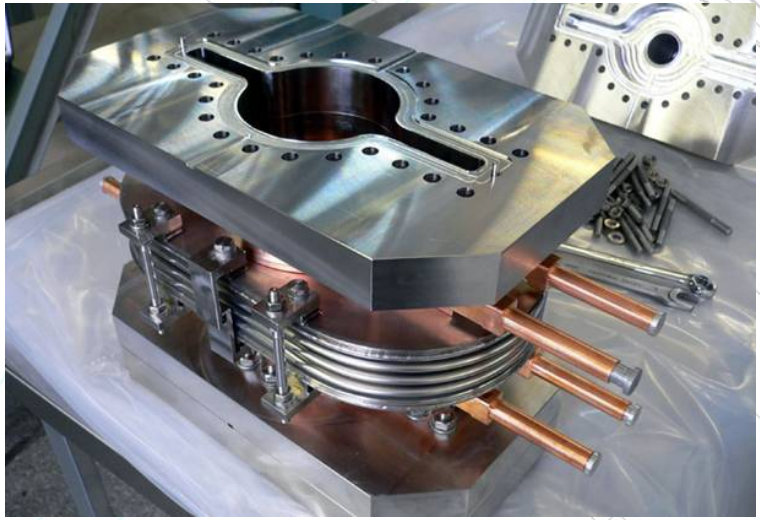
Temperature of bellows



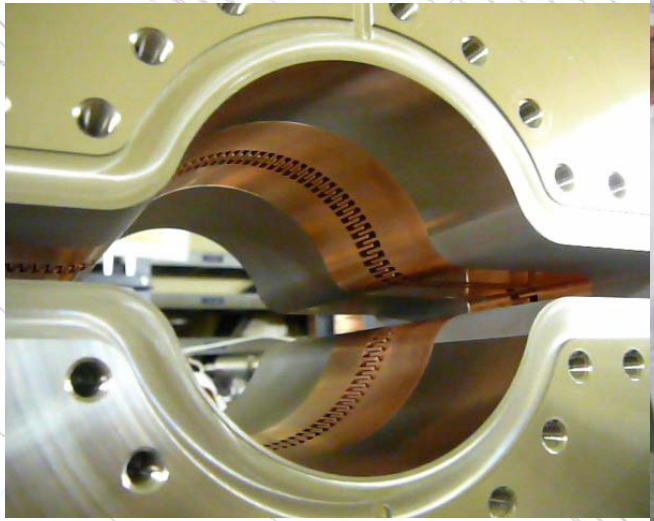
RF shielding

- Already applied to bellows chambers and gate-valves, with an aperture of beam duct with ante-chambers.
- They have been installed into KEKB and tested.

Bellows chamber

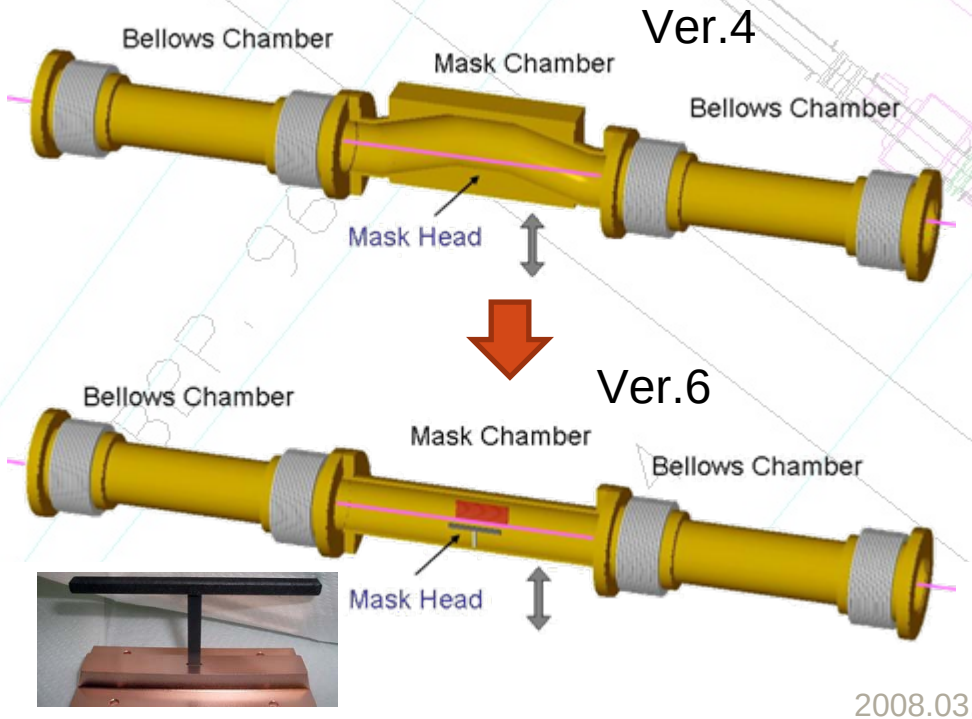


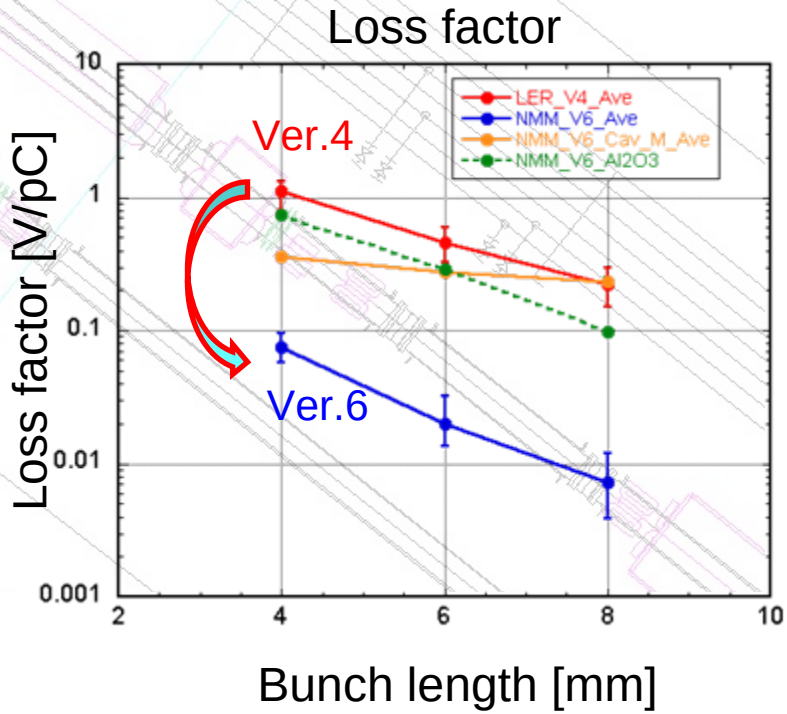
Gate-valve



Movable mask (collimator)

- Big impedance sources in the ring
- Planning to use “stealth” type (Ver.6)
  - Low beam impedance
    - Present Ver.4 ~ 1V/pC (ϕ 90 mm)→ 200 kW power loss
  - Loss factor decreases to ~1/10 (ϕ 90 mm).
    - Manageable by conventional HOM absorber

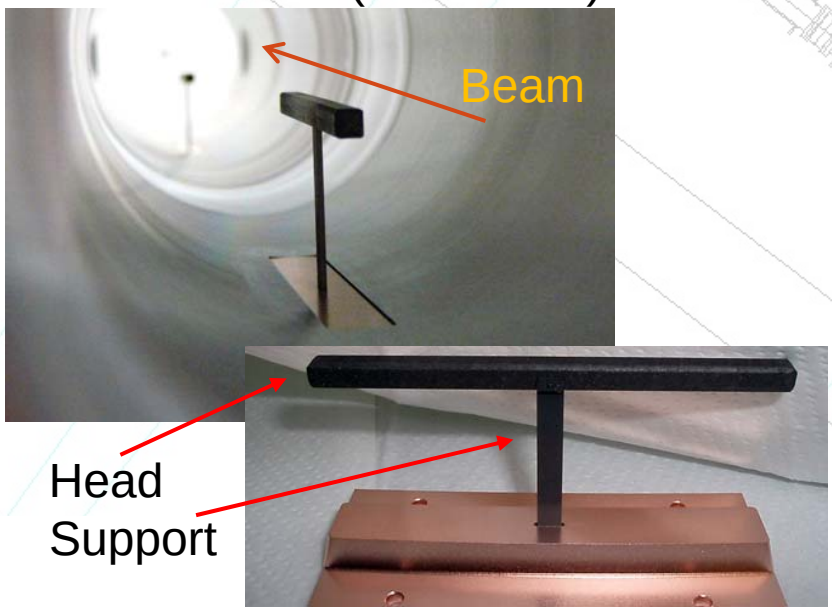




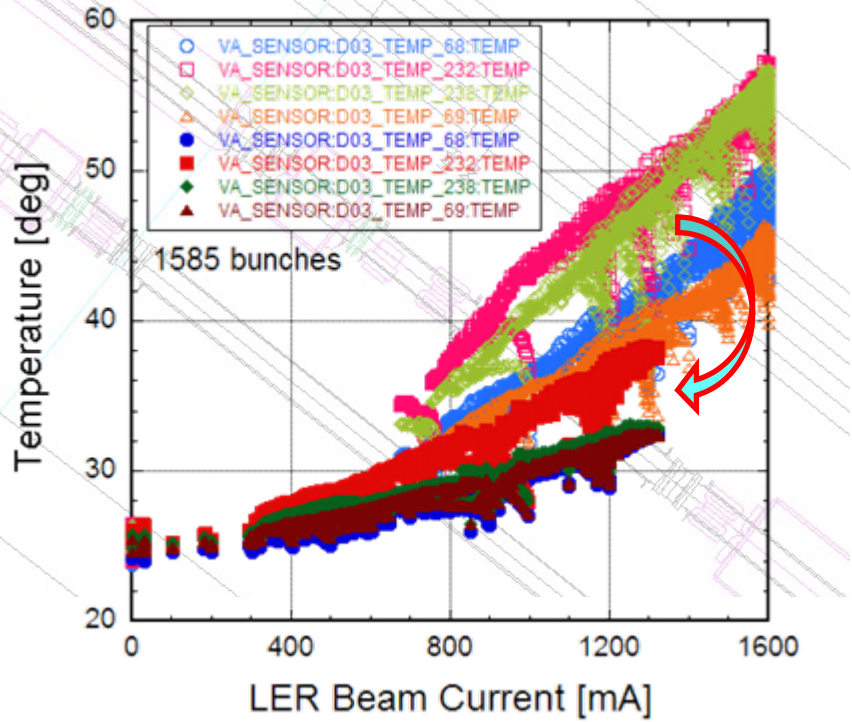
Movable mask (collimator)

- Trial models were installed and tested with beam.
  - Principle was proved experimentally.
    - Temperature rise of bellows decreased to 1/2 ~ 1/3.
  - But, could not withstand a high intensity beam yet.
- Start with Ver.4 ?
  - While beam current is low.

Head of Ver.6 (trial model)

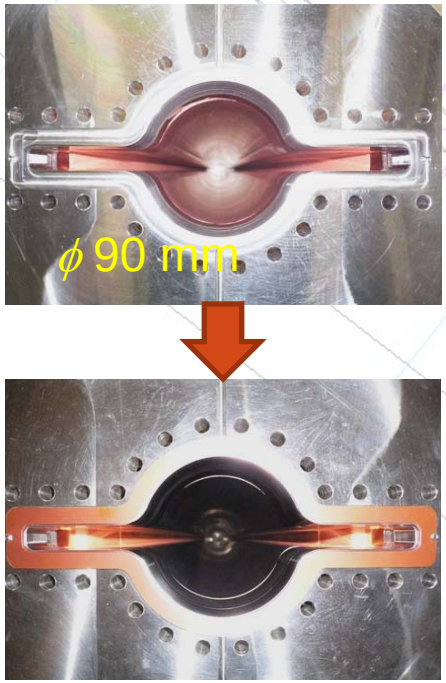


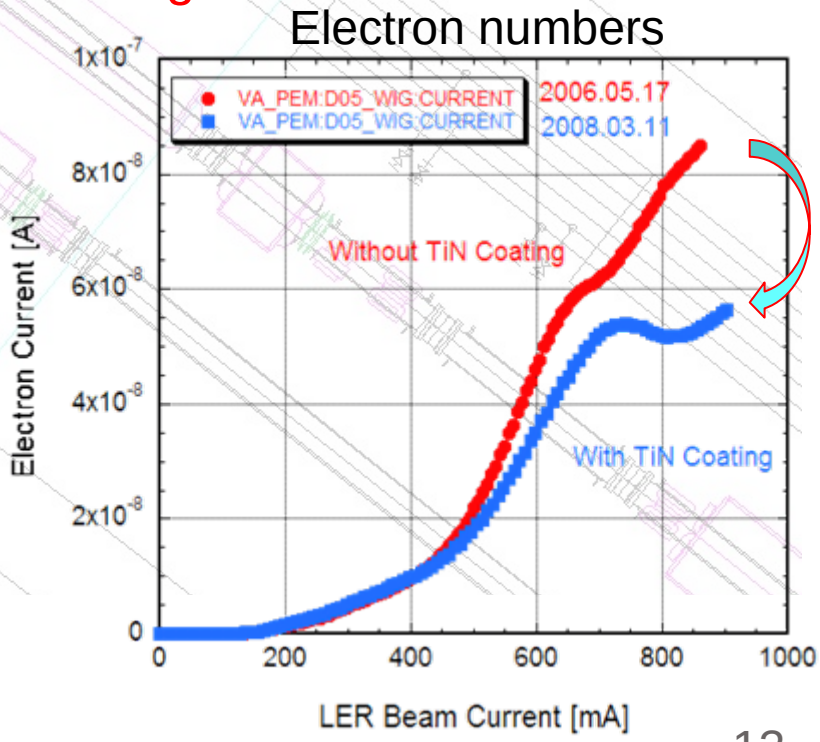
Temperature of bellows near masks



Cure for ECI_1

- A critical issue for positron ring
- TiN coating on inner surface
  - Decrease secondary electron yield (SEY): Max. SEY ~0.9
  - A test stand for the coating was built in KEK, and applied to a test duct with ante-chambers.
    - Decrease of electrons at high current region was demonstrated.

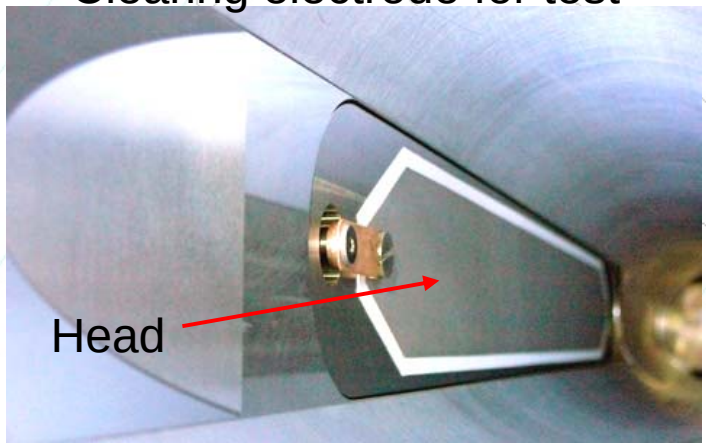


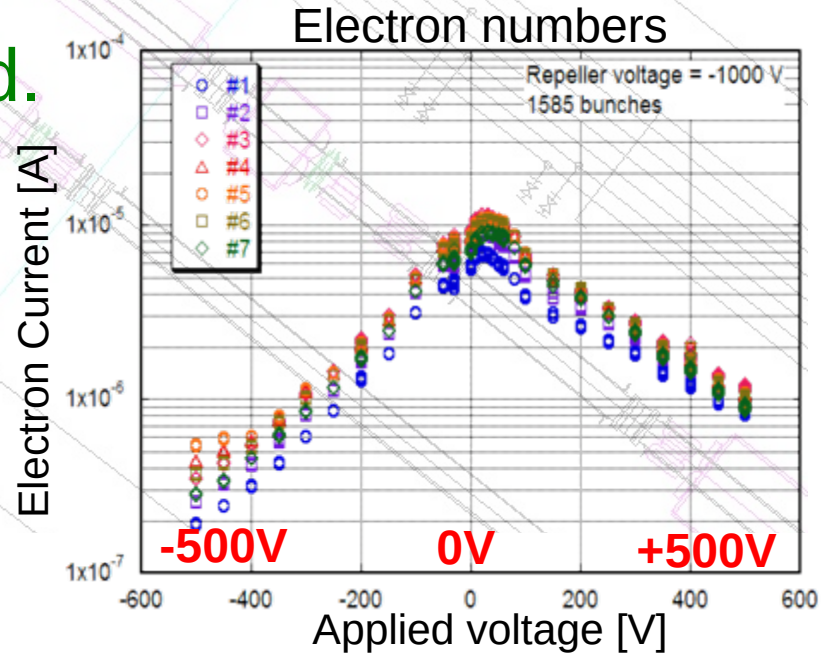


Cure for ECI_2

- Clearing Electrode
  - A possible measure even inside of magnet
- An electrode for test with a low beam impedance was developed, and tested.
  - The principle was proved experimentally.
  - Electrons decreased to ~ 1/10 by applying ±500 V.
  - Under study
- Grooves will be also tested.

Clearing electrode for test





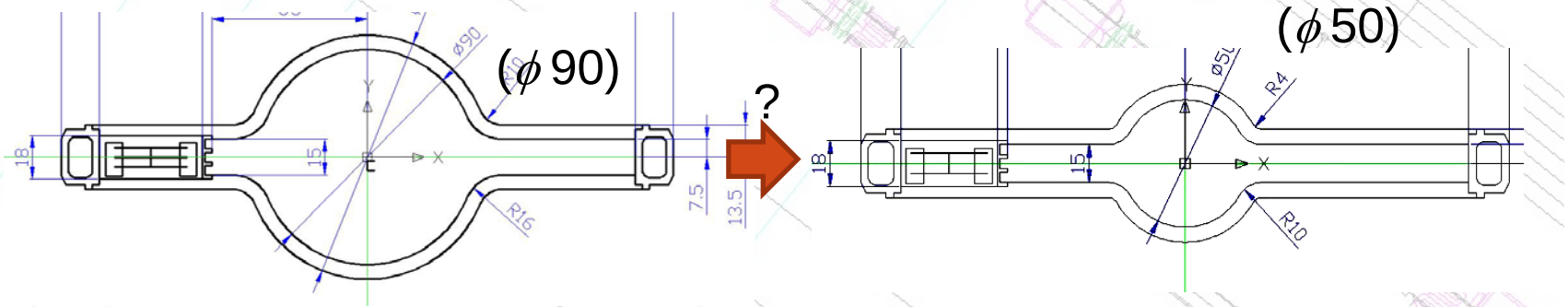
Remained issues _ Technical

- Optimization of beam duct shape
  - CSR (Coherent Synchrotron Radiation) problem have a great effect on the luminosity.

Larger aperture ← ---- → Smaller aperture

Low impedance
(ex, resistive wall)
Effective pumping

Cure for CSR
[Low cost?]



- Deformation of beam duct by heating
  - Displacement gauge for every BPM?

Remained issues _ Technical

- Required pressure
  - Now 5×10^{-7} Pa is a goal.
  - First Ion Instability require lower pressure in a simulation, ~1×10^{-7} Pa for example.
  - More pumps?
- Cures for ECI in magnet
  - Still studies are undergoing.
  - Clearing electrode ? Grooves? Only TiN?
  - Drift space: TiN coating + Solenoid will be OK.
- Design of special components
  - Septum, Abort window, HOM absorber, Cross section, …
- Design of vacuum system at IR.
  - IR optics is still floating.
  - How to keep sufficient aperture, how to deal intense SR,,

Remained issues _ General

- Cost
  - Vacuum components are more complicated than those of other machine to achieve high current, i.e., Luminosity.
  - Possibility of cost-reduction are continuously considered, such as to use aluminum duct for weak SR sections (with copper SR crotch?).
- Vendor
  - Manufacture ~2000 copper beam ducts (2 ~ 6 m long) in 3 years!
  - Find available vendors widely, all over the world.
    - Some R&D were performed with BINP, for example.
- Installation
  - Install ~2000 beam ducts and bellows in 2 years!
    - Stored place, Installation procedure, Preparation process,,
- Man power

Summary

- Upgrade of KEKB is a great challenge for the vacuum system.
- R&Ds have been performed for these years, and basic designs of key vacuum components is near completion.
- But, various practical problems are still remained.
- Any solutions should be found in this one year.

- We will appreciate your corporation.

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