Movable Mask Issues

- History of Movable Mask System -

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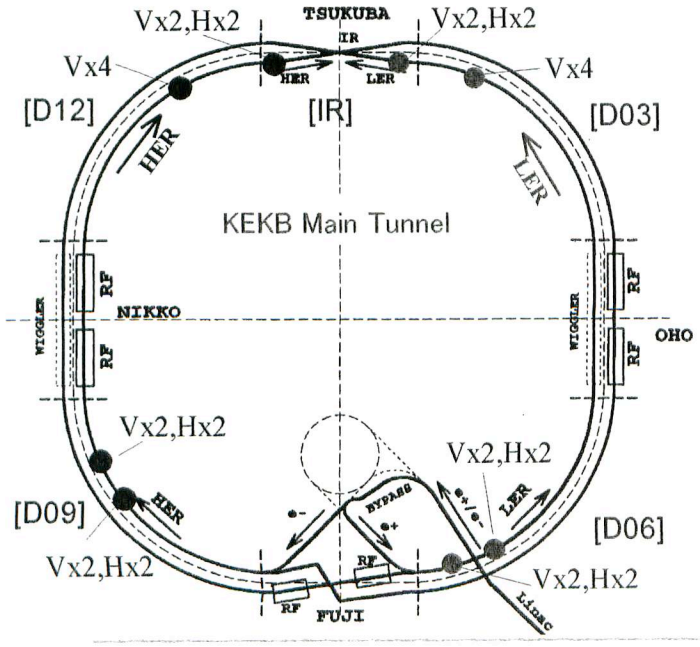
Contents

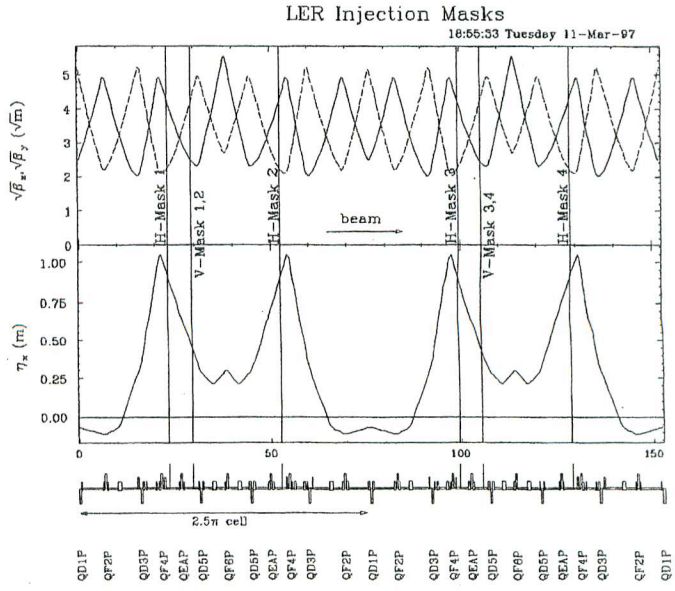
Purpose of movable mask (collimator)

Protect the BELLE detector against { off-momentum particles
particles with a large betatron oscillation

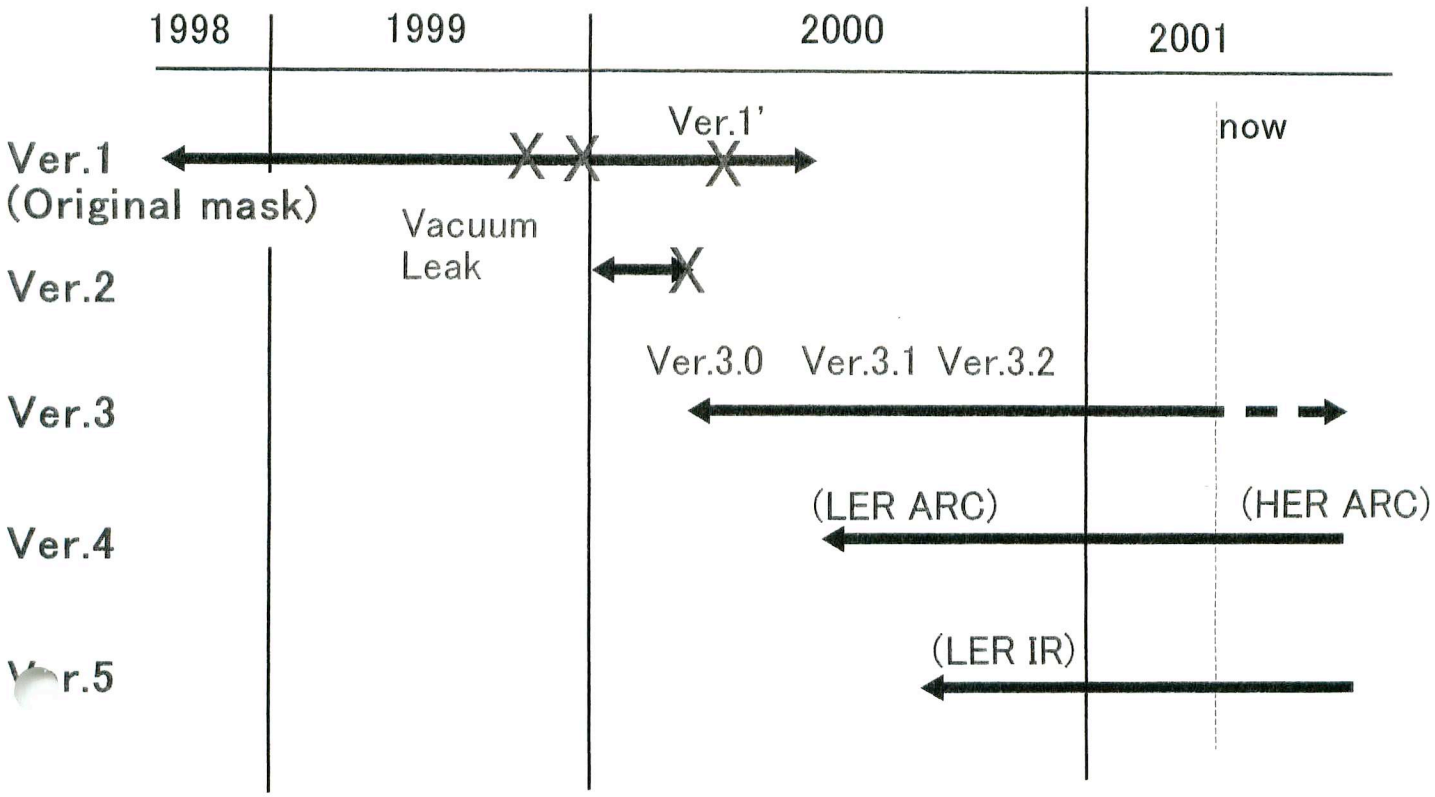
Original mask location in the ring



Location on the lattice diagram

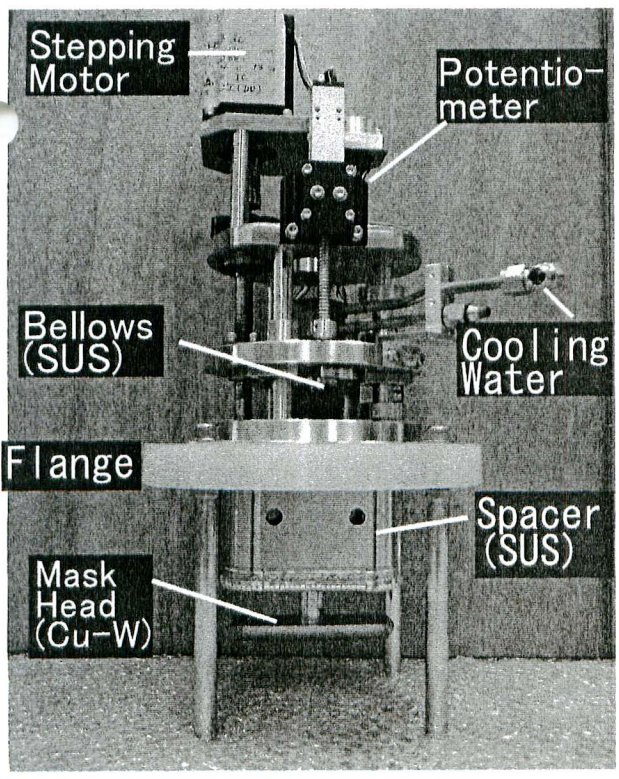


Histories of masks

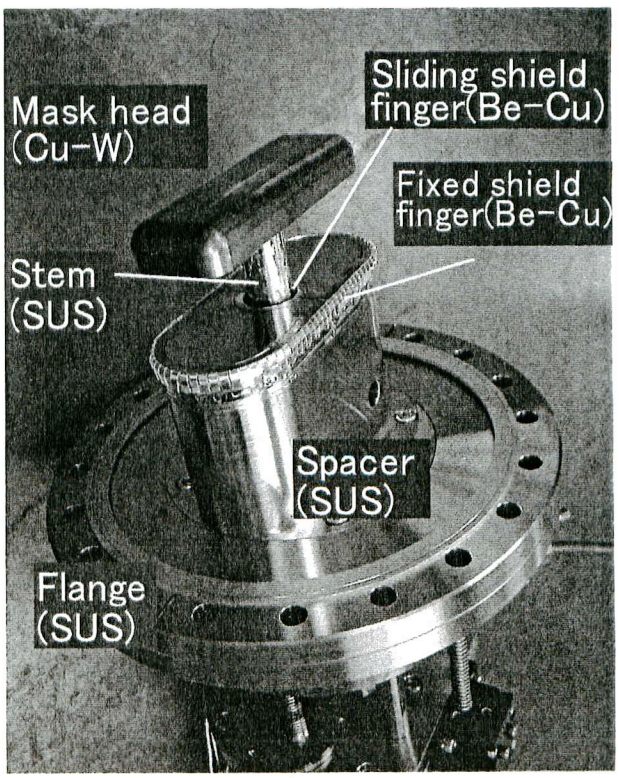


Ver.1(original mask)

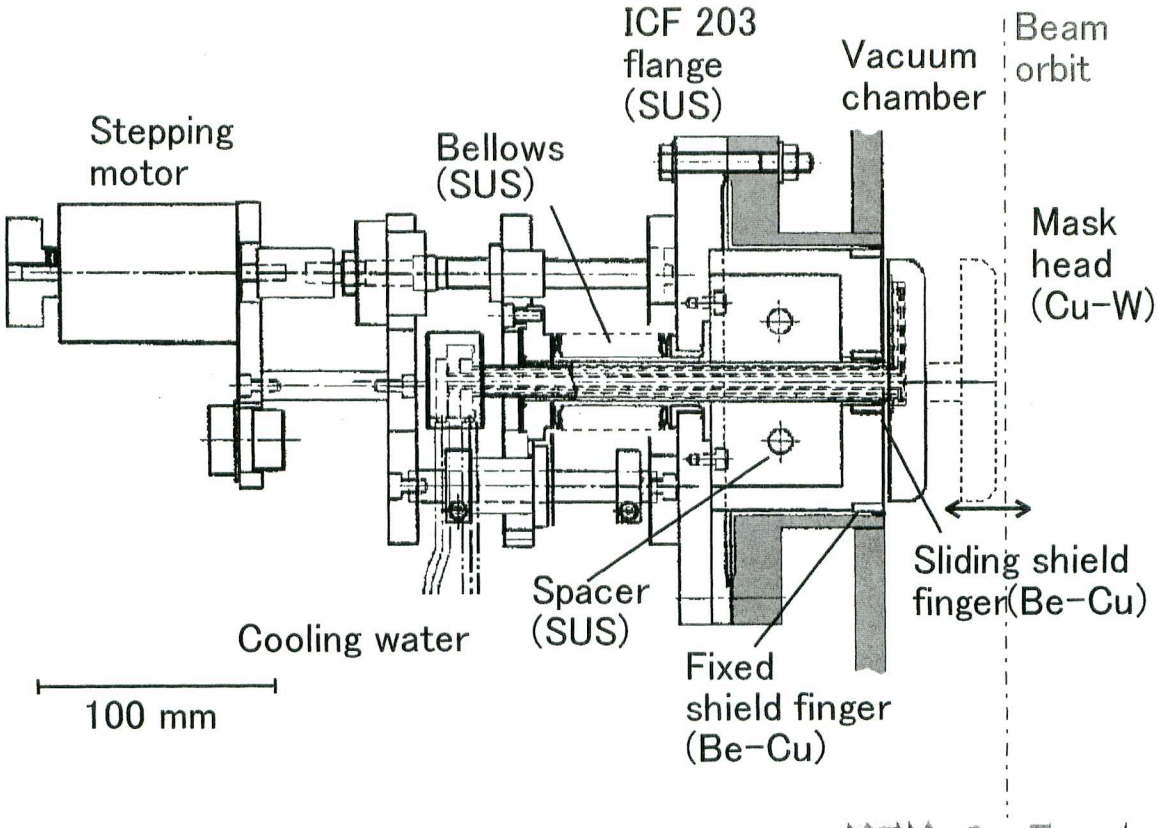
Whole view



Vacuum side

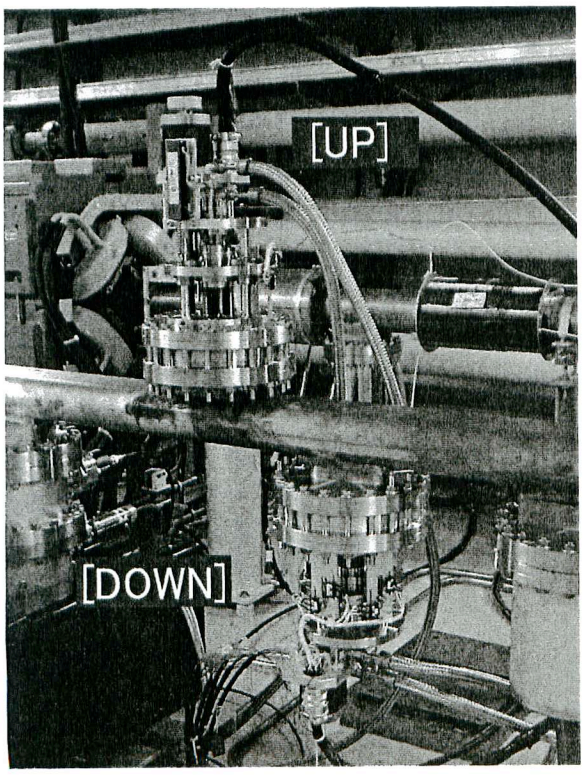


Ver.1 Structure (cross section)

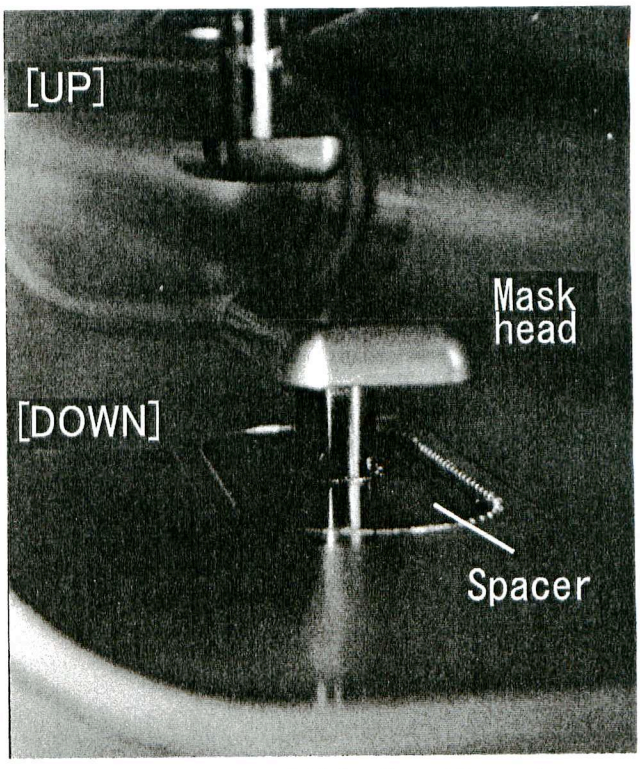


Ver.1(Ver.2 , 3) Setup in the tunnel

Outlook (HER)



Inside of beam chamber (HER)



Ver.1 Troubles (began at the beam current > 500 mA)

(1) Damage of sliding the shield fingers

Fingers were broken (melted) and welded to the stem.

(2) Excess heating

Depending on the buch fill pattern and the mask position,
the bellows temperature increased abnormally. → Vacuum leak

(3) Arcing

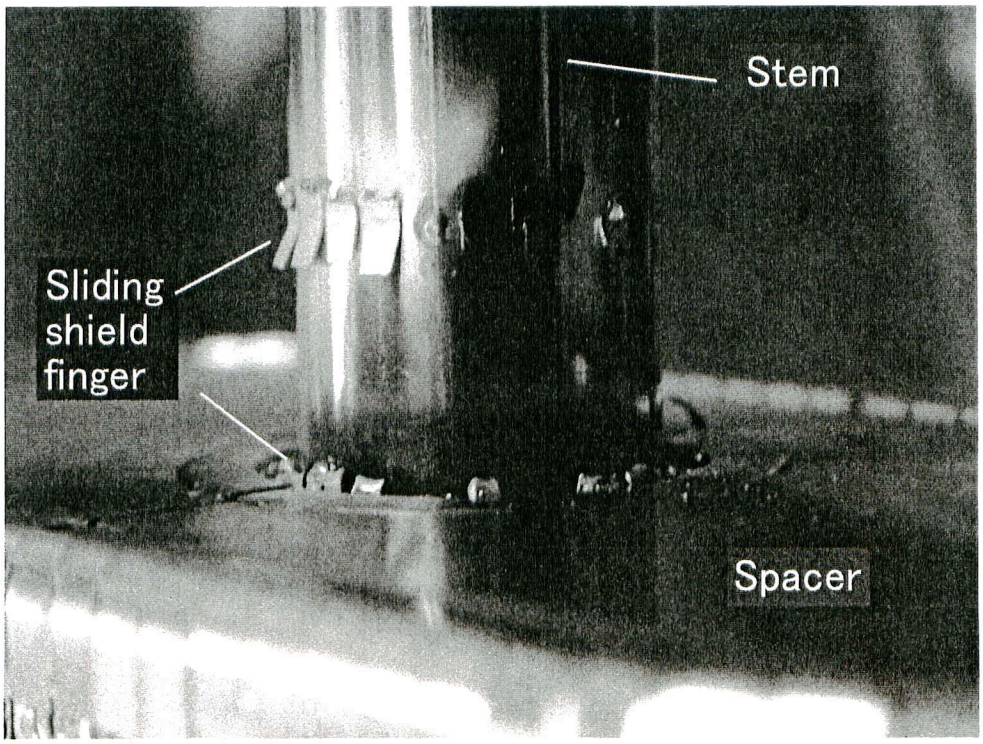
Arcing occured between the stem and the spacer.
Broken fingers became a sharp electrode for discharge.
→ Vacuum leak

(4) Excitation of beam oscillation

Strong synchrotron oscillation was excited.

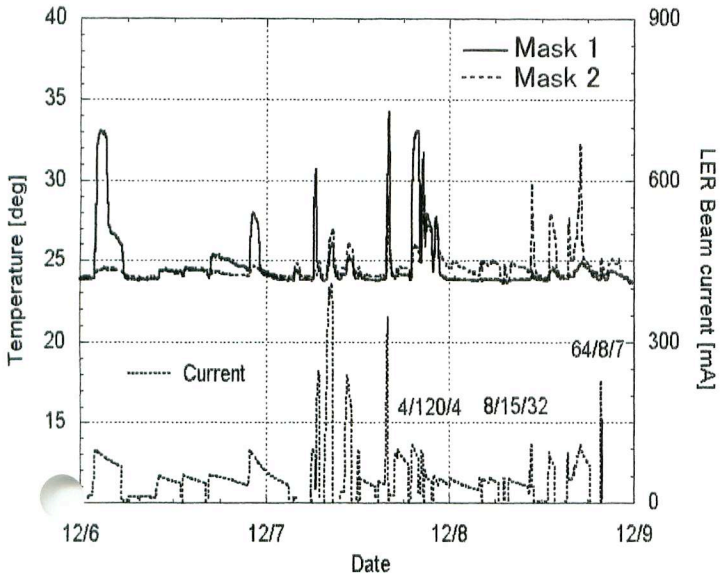
(5) Digging of mask head

Ver.1 Broken shield finger

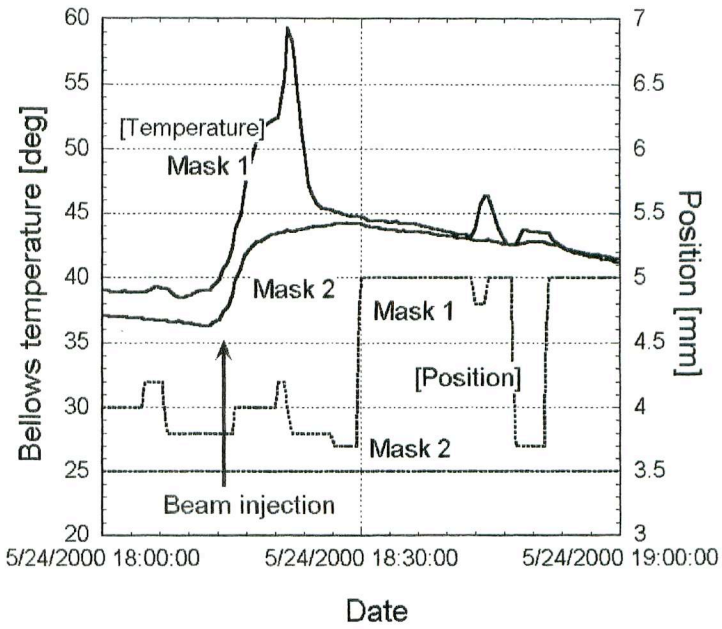


Ver.1 Excess heating

Bunch fill pattern dependence of mask temperature



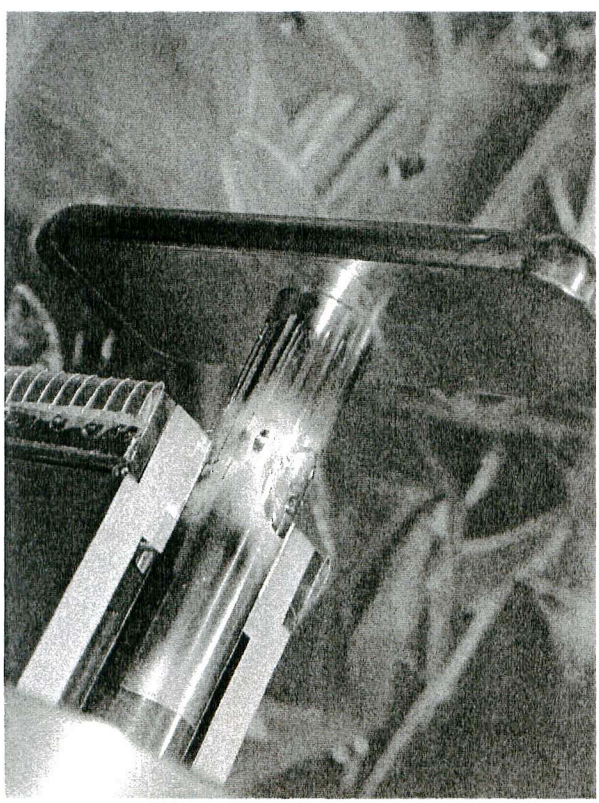
Mask position dependence of mask temperature

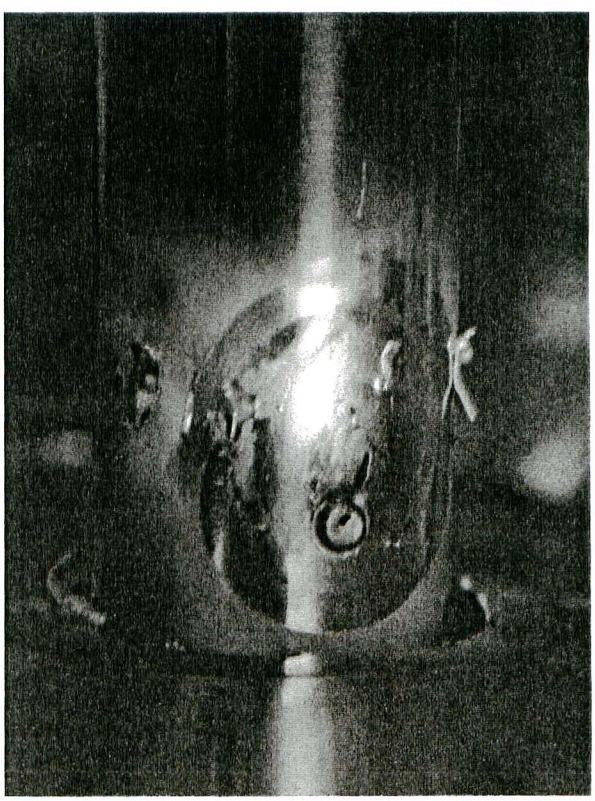


KEK B-Factory

Ver.1 Arcing between spacer and stem

→ Vacuum leak





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Ver.1 Grooves on mask head

Cu-W mask head

Ver.1 Causes of troubles

(1) Too weak shield fingers

(2) Mis-choice of materials

→ Damage of fingers → Arcing

SUS stem (bad thermal conductivity)

(3) Resonance structure → Excess heating of bellows

Coaxial cavity (stem, spacer and bellows)

→ Vacuum leak

(4) High Q trapped mode

Q～1700 (for the fundamental mode)

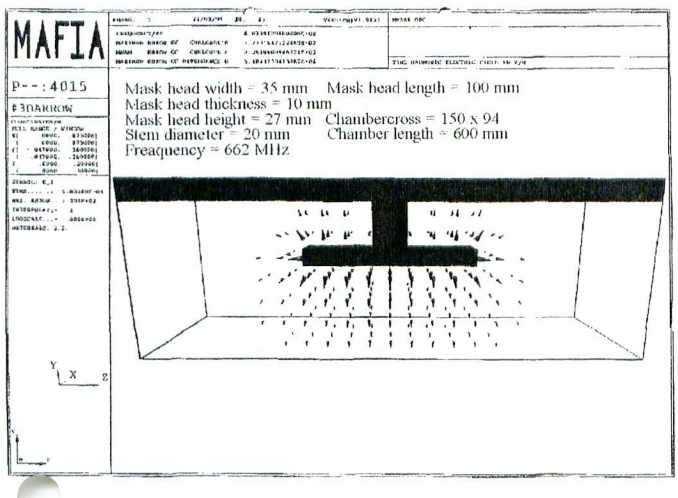
No damping structure

→ Excitation of beam socillation

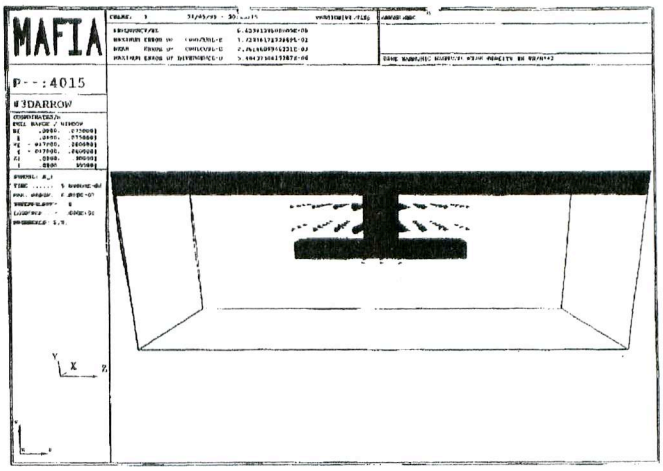
Ver.1 Trapped mode

A example of mode calculation using MAFIA code

Electric field



Magnetic field



Ver.1 Countermeasures

(1) Too weak shield finger

For the time being,
remove all sliding shield fingers → Ver.1'mask

(2) Heating

For the time being,
keep watch on temperature at bellows
and cool the bellows by a blower

(3) Resonance structure

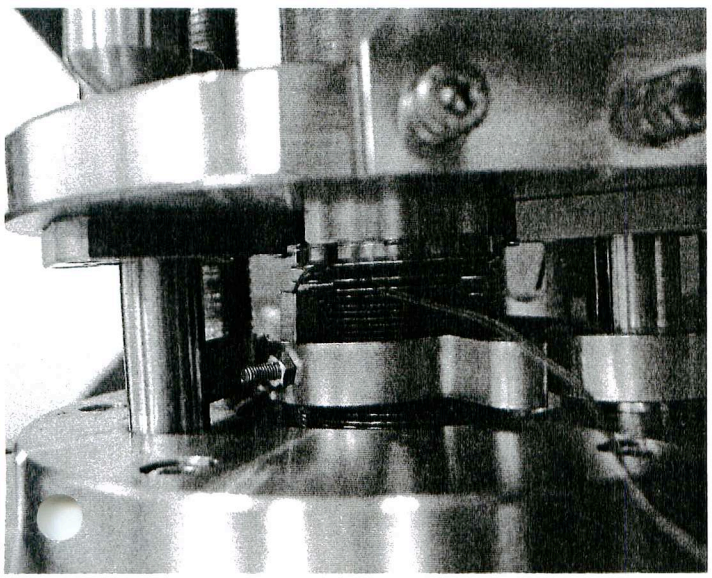
(4) High Q trapped mode

→ Design of new masks
well coped with heating
and RF problems

(5) Digging of mask head → Change of mask head material
CuW --> Cu

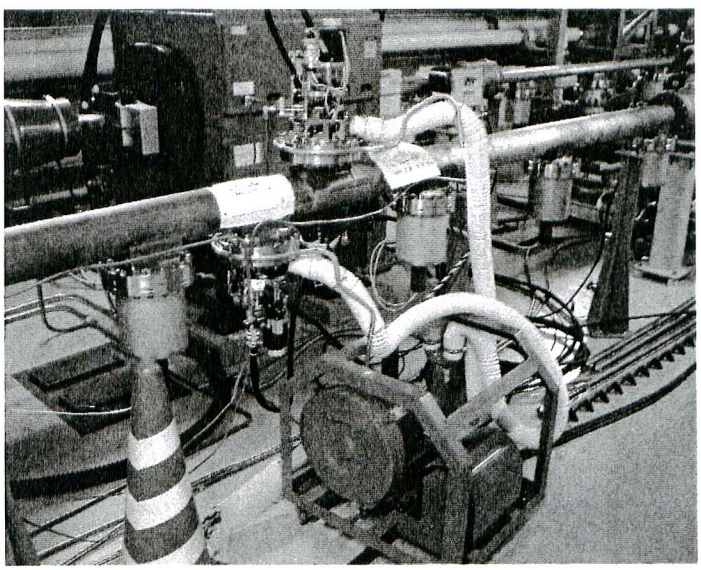
Ver.1 Countermeasures for the time being

Thermometer (PtR) at bellows pleats

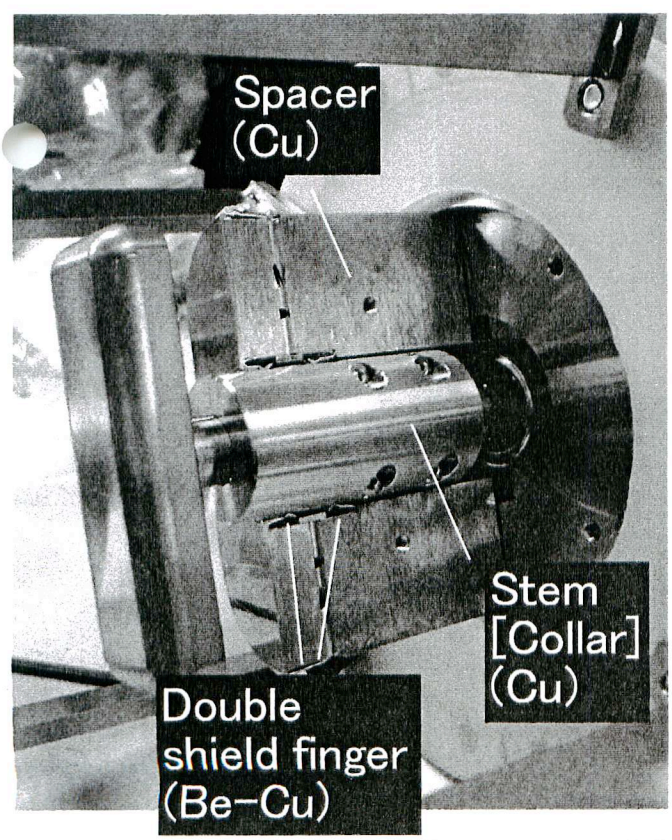


(Platinum resistance thermometer)

Cooling by a blower



Ver.2 (prepared to meet an immediate need)



Features

- Low current density at the sliding shield finger (Stem diameter 16 mm --> 36 mm)
- Double sliding shield finger

But

- Q factor is still high (~2000) RF properties are the same as Ver.1

Ver.2 Troubles

When the Ver.2 masks were approaced to the beam,
a strong synchrotron oscillation was excited.

↓

→ Limit the current

All Ver.2 masks were set at full the open position.

↓

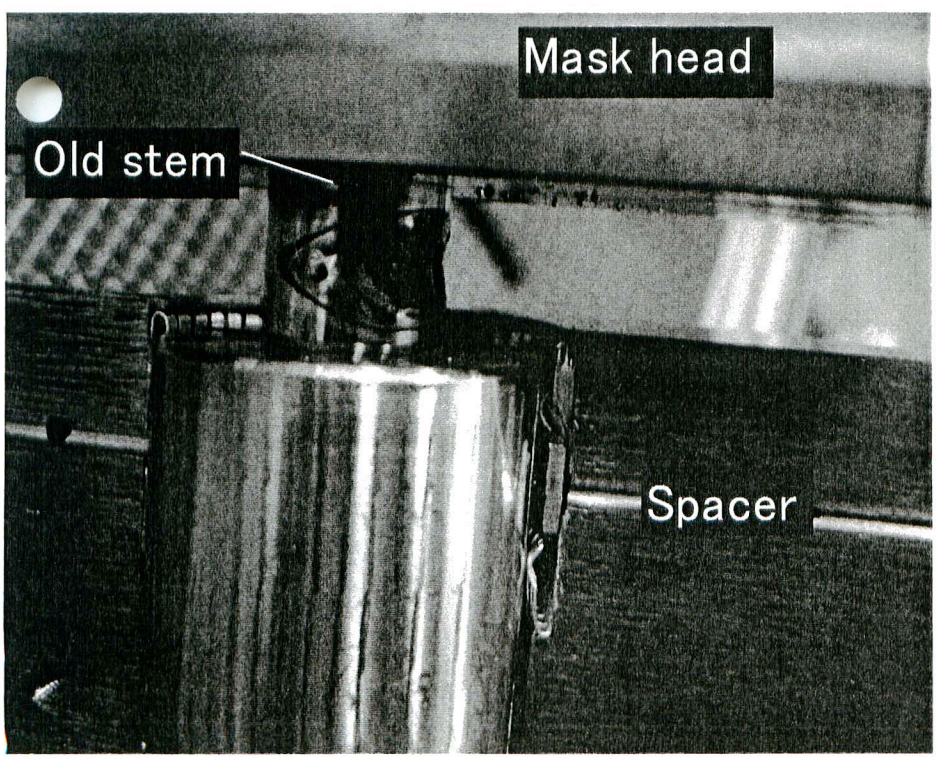
Arcing occured between the old stem (inside of collar)
and the edge of spacer.

↓

Vacuum leak !

Ver.2 Vacuum leak

Arcing between the old stem and spacer



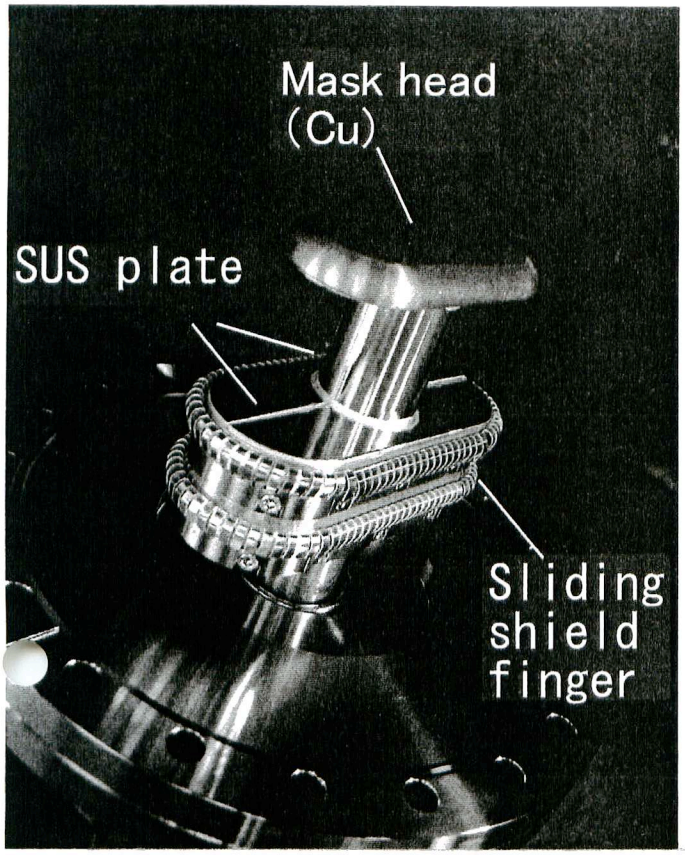
↓

All Ver.2 masks were
immediately removed.

(Very short-lived mask)

Ver.3.0 – 3.2 (After all, a fillar until new masks are prepared)

Ver.3.0



Features

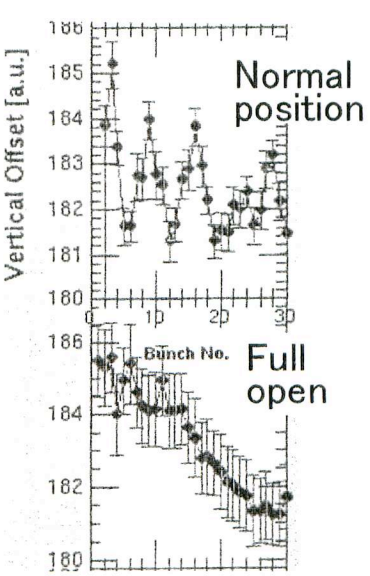
- Low current density at sliding shield finger (around spacer)
- Double shield finger
- Low Q (～600) compared to Ver.1

  with SUS plate
- Existing chamber is available
- Cu mask head
  (CuW --> Cu)

Ver.3.0 Troubles

The Q-factor was still too high.

- A synchrotoron oscillation was excited again.
- COD in a bunch train was observed.



↓

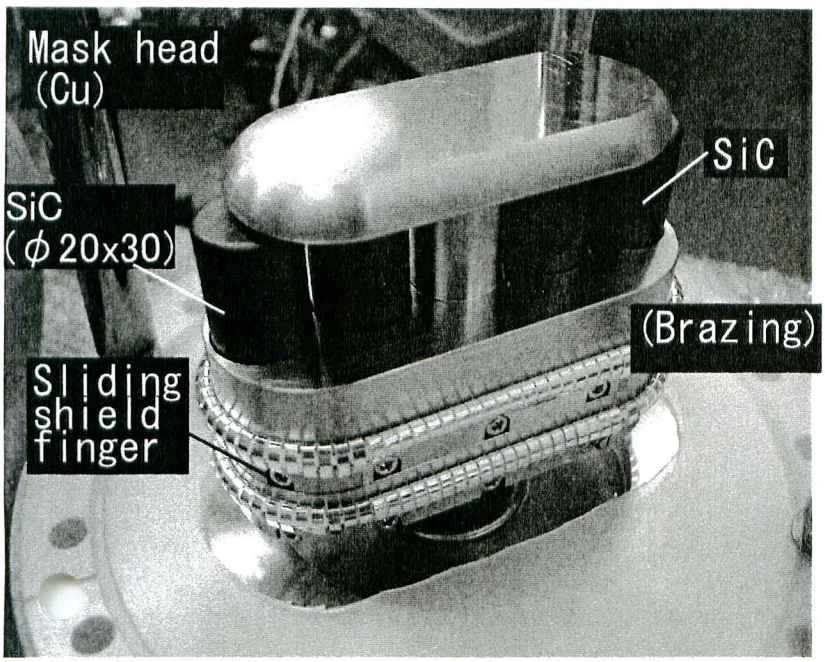
The mask head was set at the full open position.

↓

Ver.3.1 and Ver.3.2 masks with RF damping structure were developed.

Ver.3.1, 3.2

Masks with HOM damper



Features

- Basic structure is the same as Ver.3.0.
- HOM damper (SiC) is equiped.

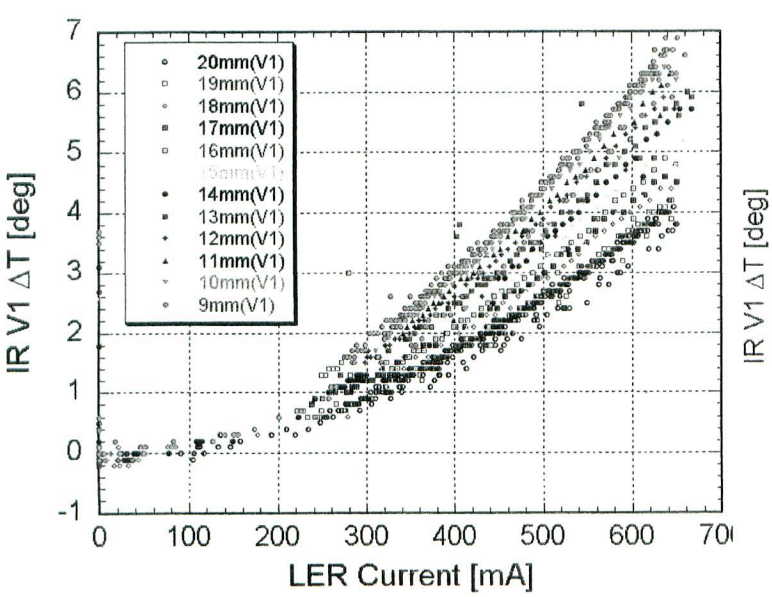
  Low Q (~40)

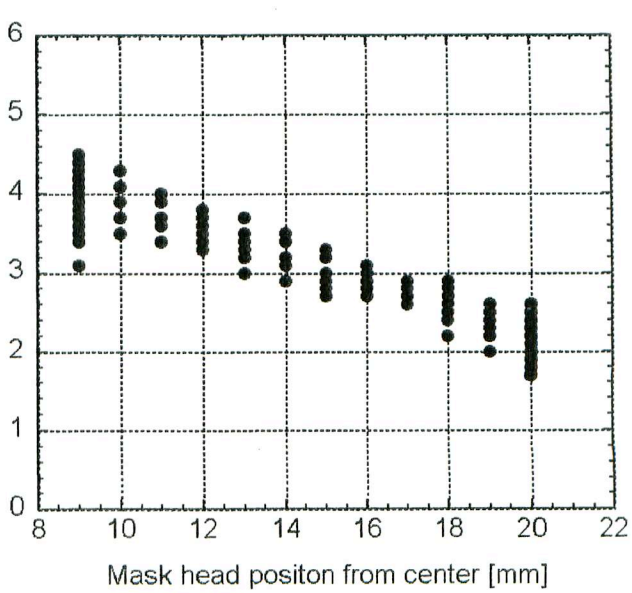
- In calculation, the input power of SiC is reasonable unless the frequency of a trapped mode and that generated by the beam are mached.

Ver.3.1 Troubles

Larger input power than expected ~500 W/SiC at 600 mA (LER)

The temperature increased monotonically as the mask head approached the beam. → Not a resononace → The SiC is absoribng HOM generated at the mask itself.



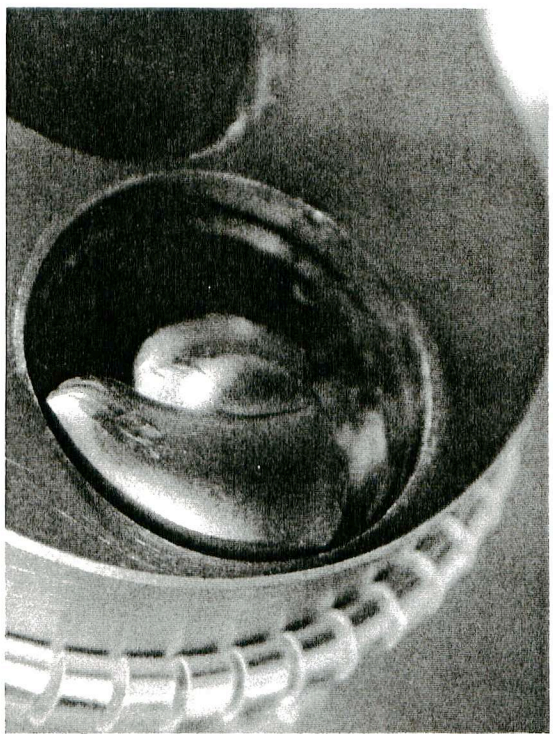


Ver.3.1 Troubles

An SiC has broken

After the operation at 700 mA for about 2 monthes, one SiC was found to be broken.

Before installation?
Too high input power?



LER beam current was limitted at

500 W/SiC (larger than the past achievement)

↓

To play it safe, Ver.3.1 cannot be usedfor LER anymore.

↓

New masks Ver.4, 5

Ver.3.2 (temporally prepared for HER vertical)

Ver.3.2

(Before attaching sliding shield finger)

Features

- Basic structure is the same as Ver.3.1
- The height of Sic was shorten to half 30 mm --> 15 mm

Now HER beam current was limitted at

Maximu input power
< 250 W/SiC

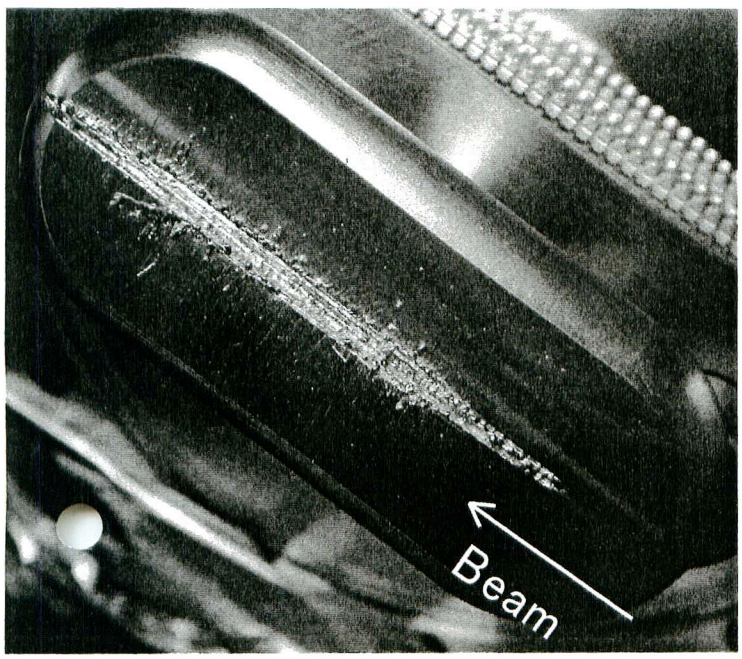
↓

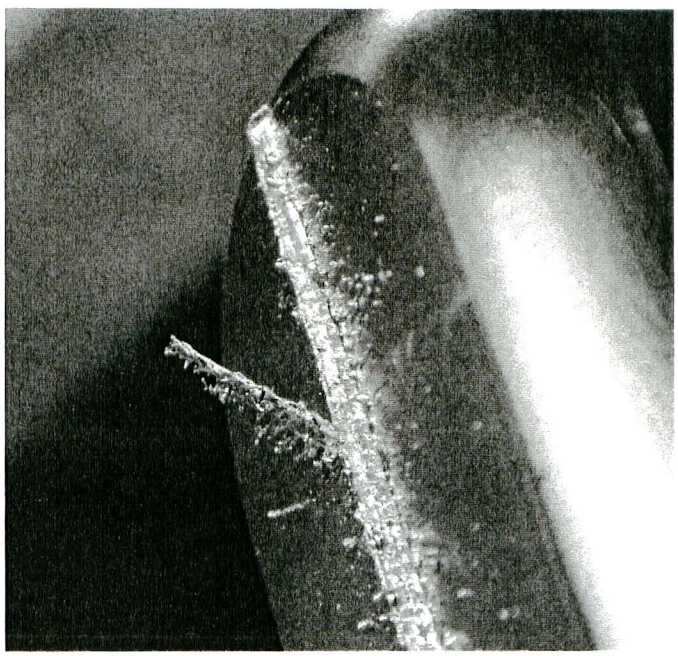
Ver.4

Ver.3.2 Troubles

Groove on the mask head (Cu)

The head has melted. The whisker was objecting the beam.





Groove on mask head

Possible Cause

(1) Abrupt change of orbit

Setting of a abnormal bump

(2) Vertical blowup of beam size or vertical oscillation

One possible stroy

Energy loss (a few %)

For an example, down of a (superconducting) cavity

↓

Slippage from the regular optics or feed-back timing

↓

Vertical blowup of beam size or vertical oscillation

↓

Generation of groove (further study is necessary)

{ Fast loss monitor
Fast sensor of RF phase

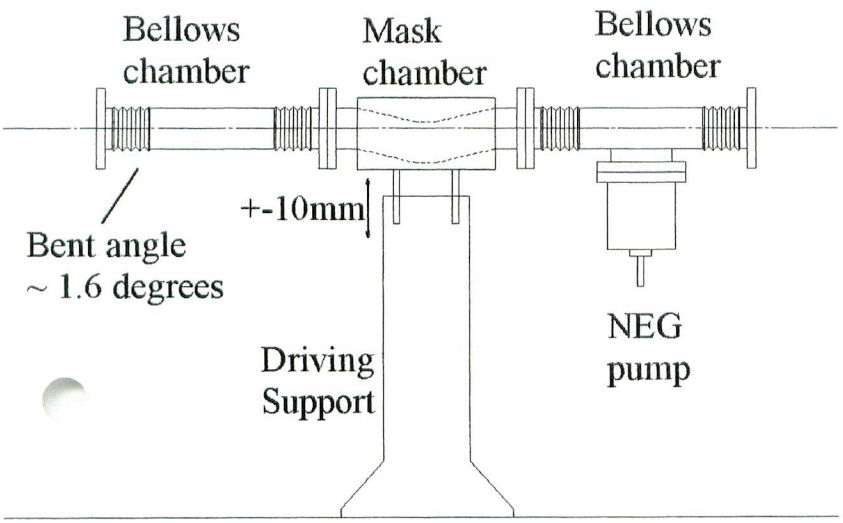
may help mask

The problem will be occured even for new masks.

Ver.4 (the ultimate weapon for arc section)

Basic structure

Use a bent chamber as a mask.



Features

- Free from trapped modes (HOM is excited.)

But

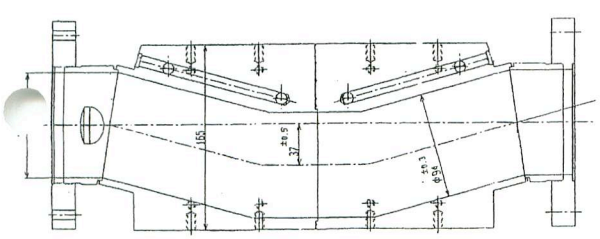
A space of several meters is necessary.

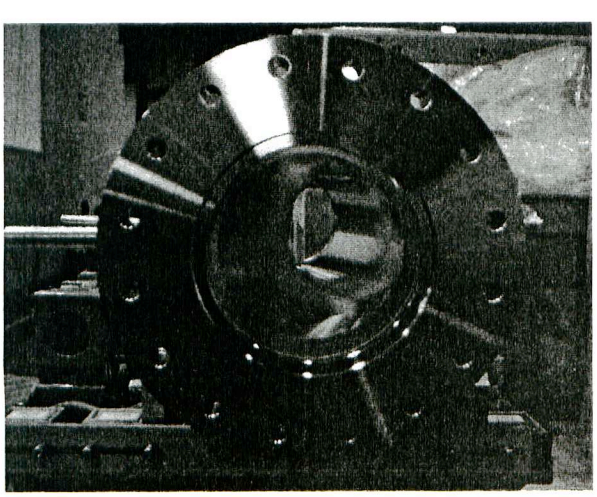
↓

Available for arc section

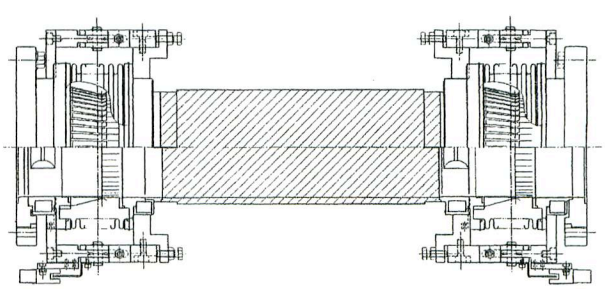
Ver.4 Components

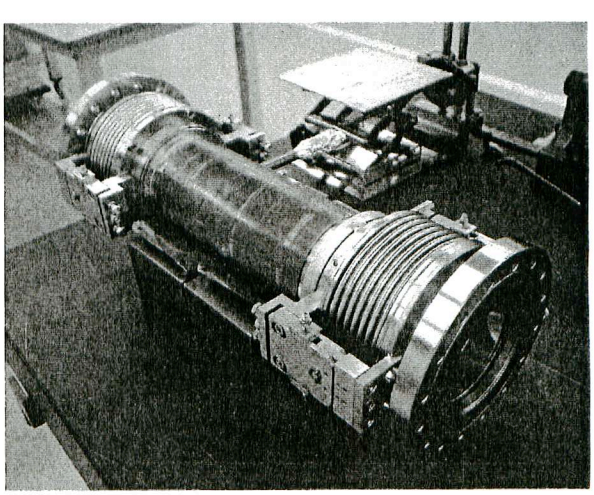
Mask chamber (LER)



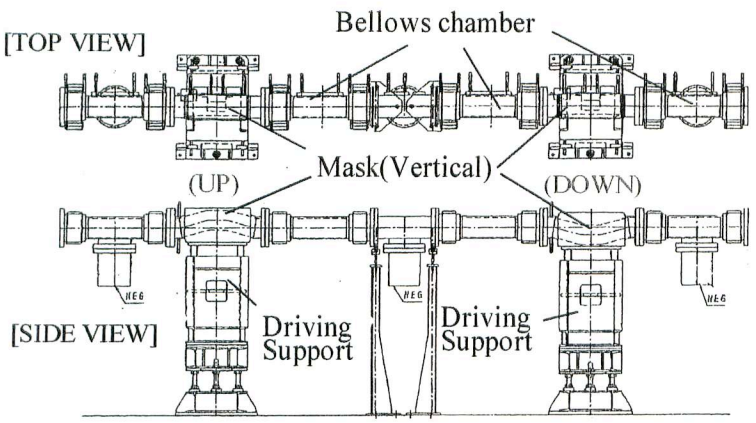


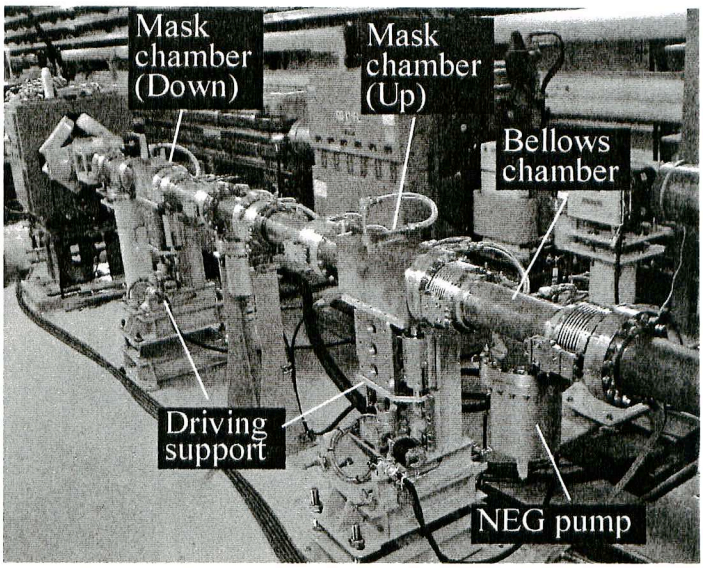
Bellows chamber (LER)





Ver.4 set up in the tunnel (vertical)





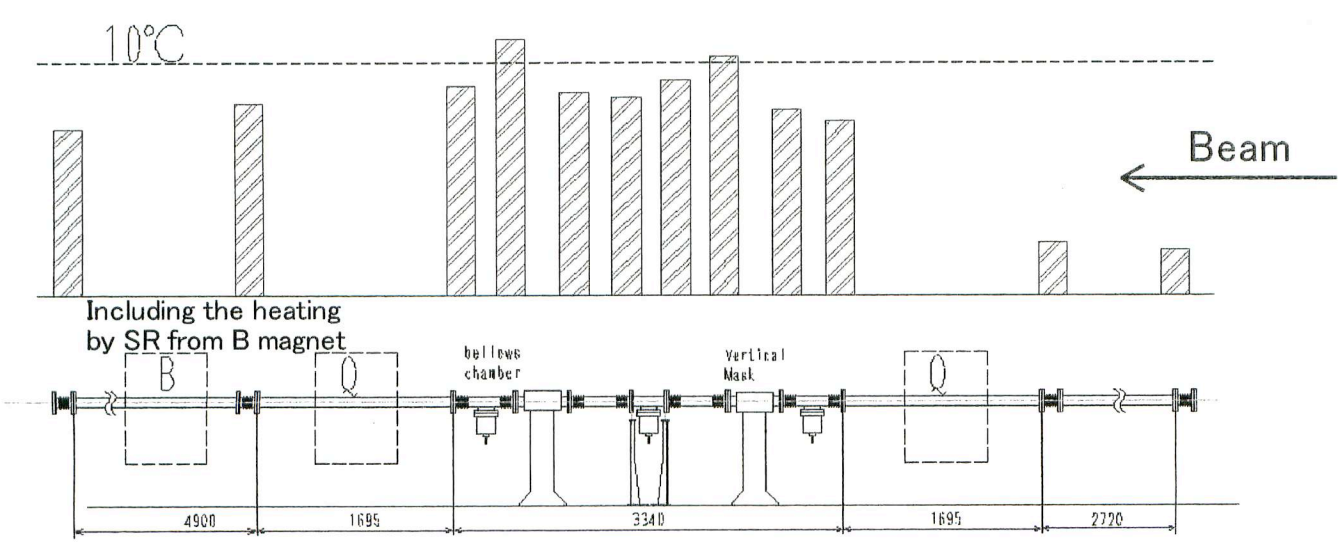
KEK B-Factory

Temperature rises of bellows around Ver.4 masks

Temperature rises at bellows around Ver.4 masks are higher than other bellows.

Temperature rise at 600 mA (LER)

Max. $\Delta t = 35^{\circ}C$



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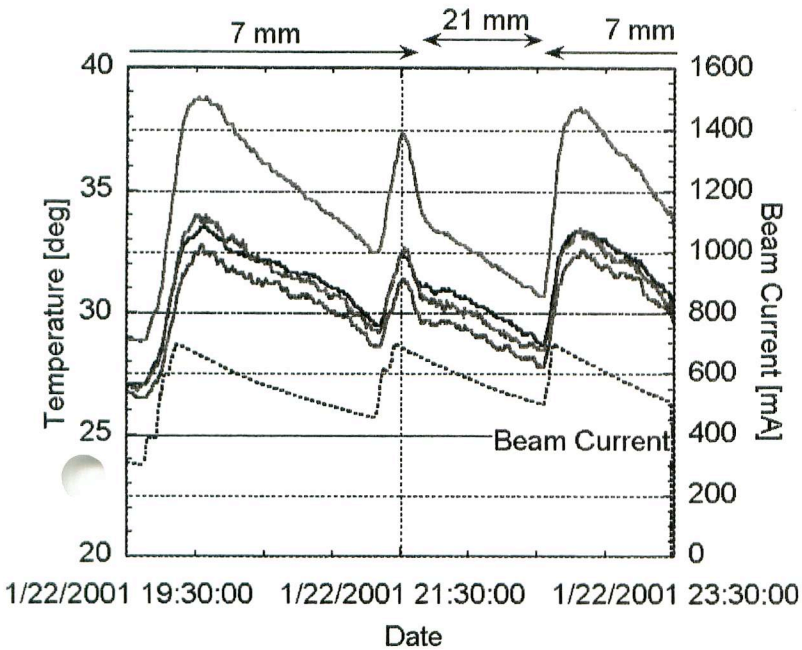
Temperature rise of bellows

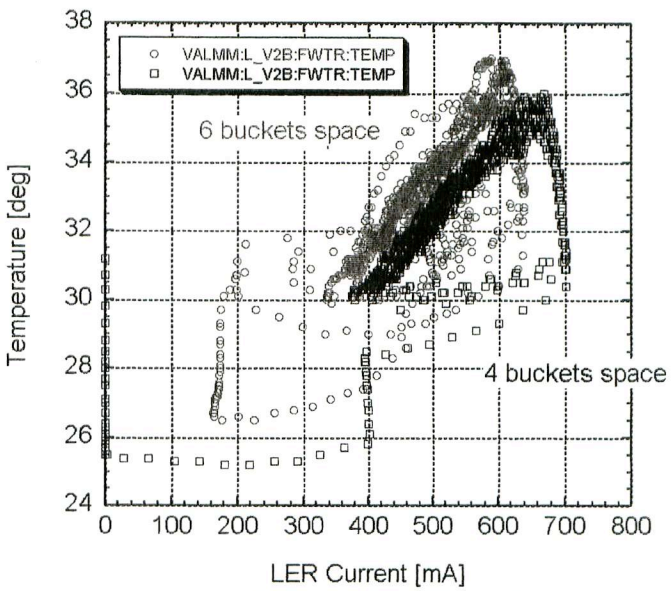
Due to { HOM generated by the mask? / scattered SR?

Mask position dependence of bellows temperature near masks.



Fill pattern dependence of bellows temperature near masks.

Linear?



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Present status of Ver.4 mask

(1) There is no fatal trouble up to now.

- Maximum beam current is 780 mA (LER).
- No grooves was found for LER up to now.

(2) Temperature rise of bellows near Ver.4 mas is higher than others

- Main cause is HOM and/or scatterd SR?

  Further studies are necessary.
- We have to keep watching.

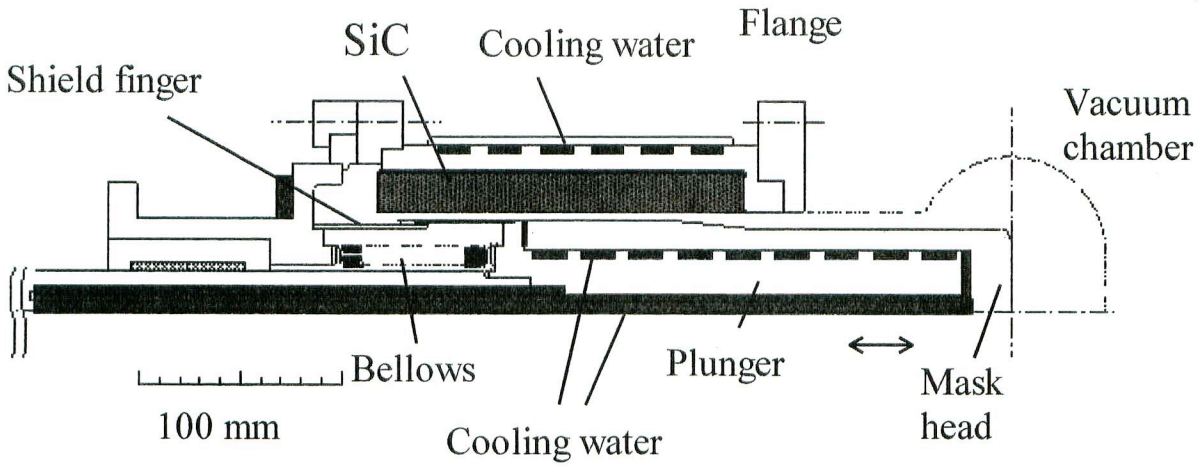
(3) Check of grooves at regular intervals is necessary.

Prepare peeking hole for HER masks and spare masks.

KEK B-Factory

Ver.5 (the ultimate weapon for IR)

Structure (cross section)



Features

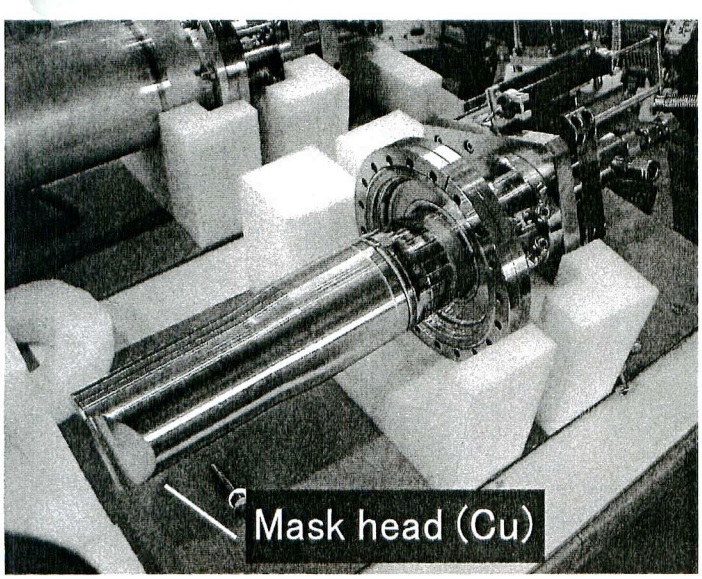
HOM is heavily dumped by SiC dumper.
$Q < 10$

Designed power capaciy is 10 kW

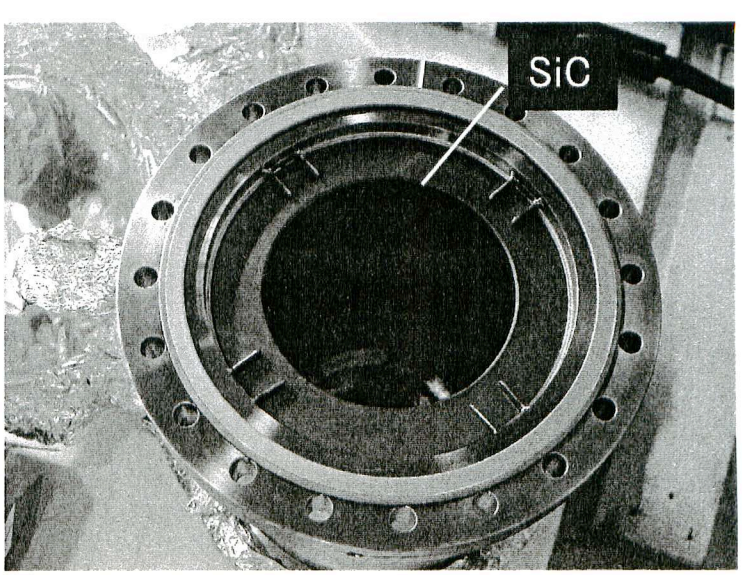
Avalilable for narrow space

Ver.5 Components

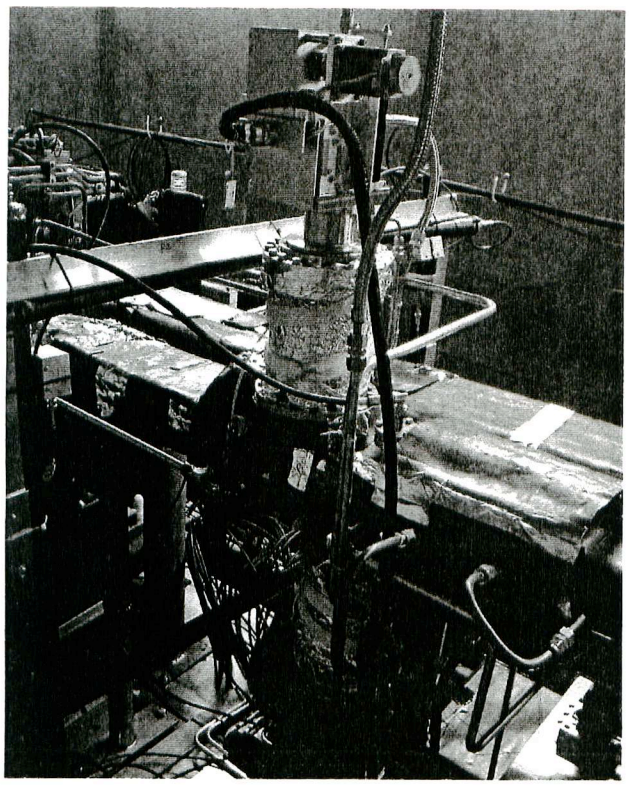
Mask (plunger)



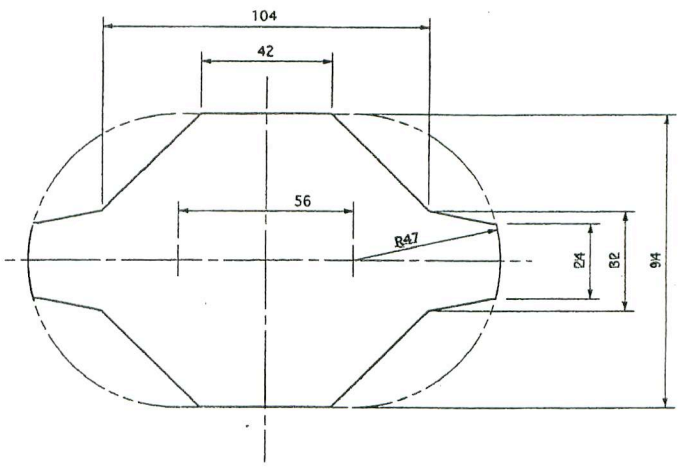
SiC duct (HOM dumper)



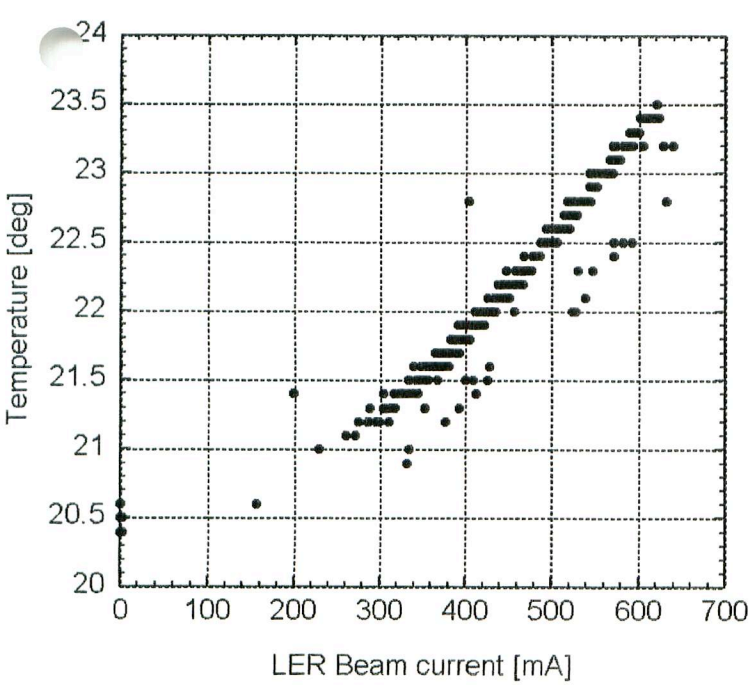
Ver.5 set up in the tunnel for LER IR (Vertical)



Cross section of the chamber is changed to adjust the mode frequency
.



Present status of Ver.5 mask



(1) Estimated input power

~800 W at 500 mA

↓

~4 kW at 2600 mA

No problem

(2) Check of grooves at regular intervals is necessary.

Summary

(1) Old masks (Ver.1 - Ver.3) had various problems and troubles.

Excess heating, Arcing --> Vacuum leaks
Excitation of beam oscillations

Mask problems had been limitting the stored beam currents.

(2) New masks (Ver.4 and 5) well coped with RF and heating problems are developed

They are working well.

(3) All masks in HER arc will be replaced to Ver.4.
All masks in the KEKB are changed to new ones this year.

(4) Grooves on mask head have to be kept watching

Fast abort system should be prepared.