Improvement of Movable Mask System for High Beam Current Operation in 2002

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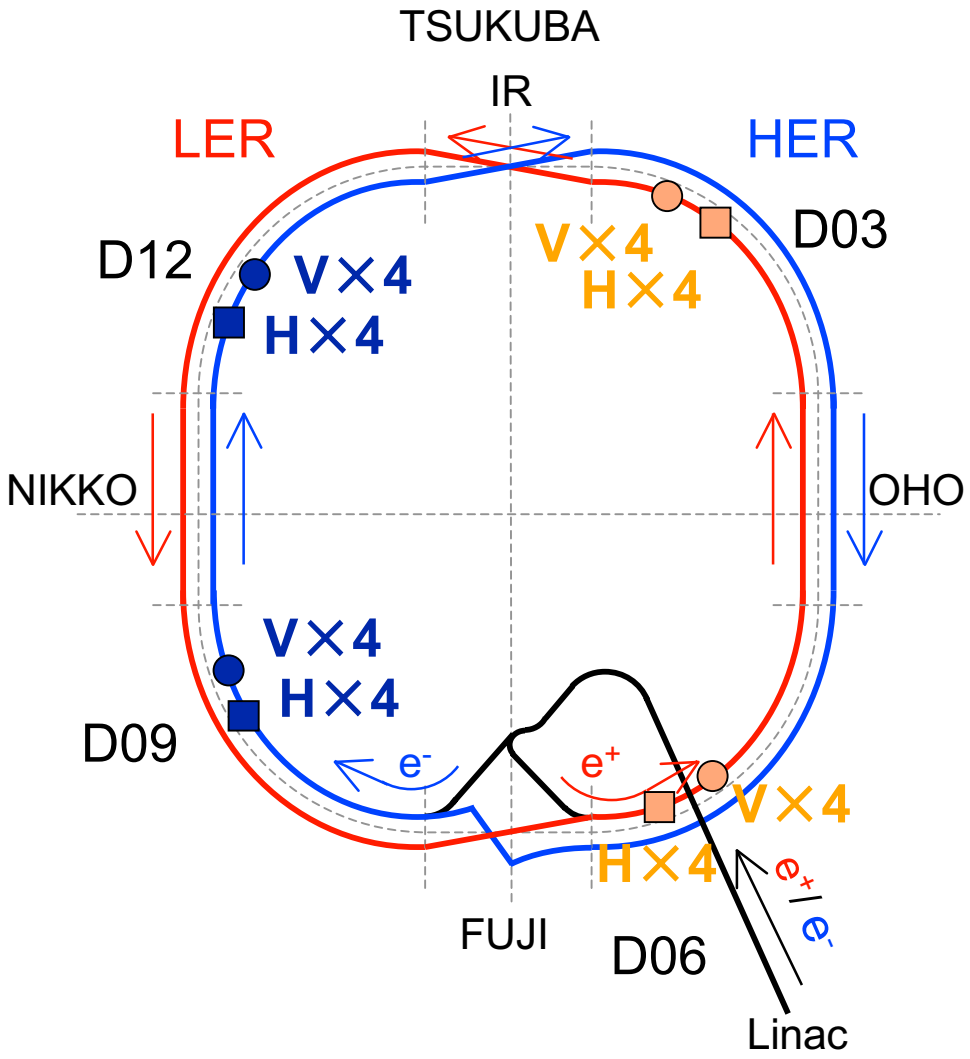
Introduction

- Installed Movable Masks (present)



- Improvements in 2002
  - Vertical Mask
    HER D12
    Installation of Movable Mask with Reduced HOM Design
  - Horizontal Mask
    LER D03
    Installation of Winged HOM Damper near Movable Masks
  - Mask Head
    D03 V-Masks
    Change of the material from Cu to Ti
  - IR
    Remove of Movable Masks

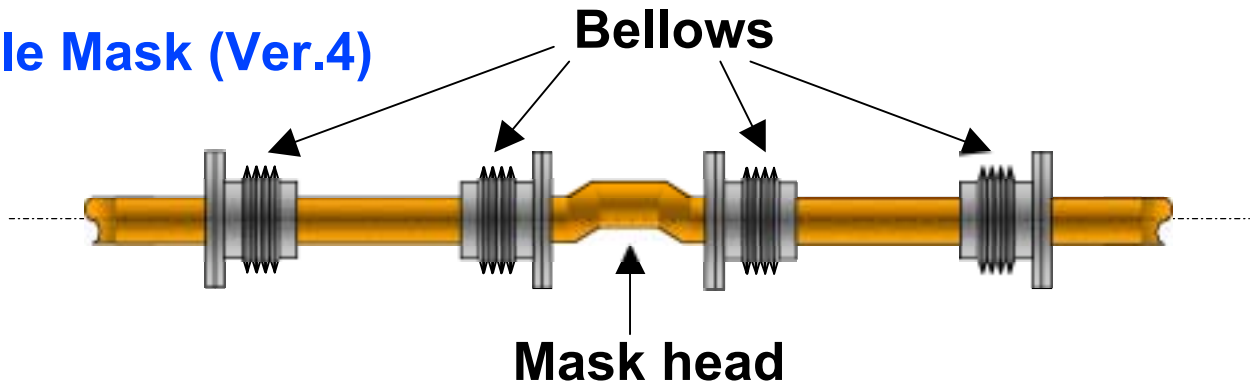
Movable Mask with Reduced HOM Design 1– Problem

- Overheating of bellows just near the V-Mask in HER at the beam current higher than 900 mA

Cause

- The HOM was excited at the mask head and went along the beam duct.
- The TE-Mode HOM went inside of the bellows through slits between RF shield fingers.

Movable Mask (Ver.4)



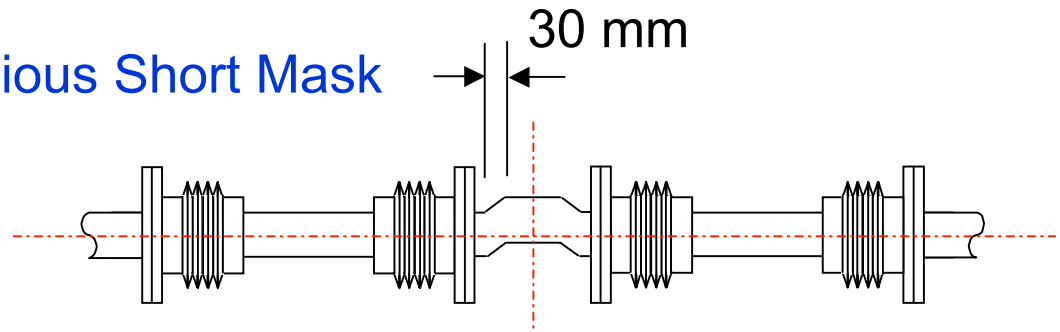
Countermeasure :

Development of improved movable mask with reduced HOM design (Extension of the ramps of the mask)

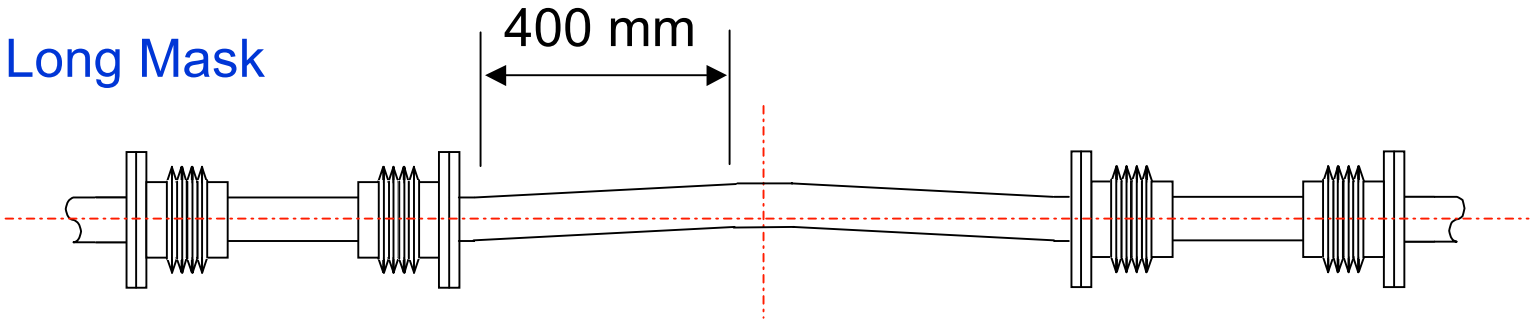
Movable Mask with Reduced HOM Design 2 - Design

- In order to reduce the power of TE-Mode HOM, the length of ramps beside the V-Mask head was expanded from 30 mm to 400 mm.
- The height of both mask is same. (15 mm)

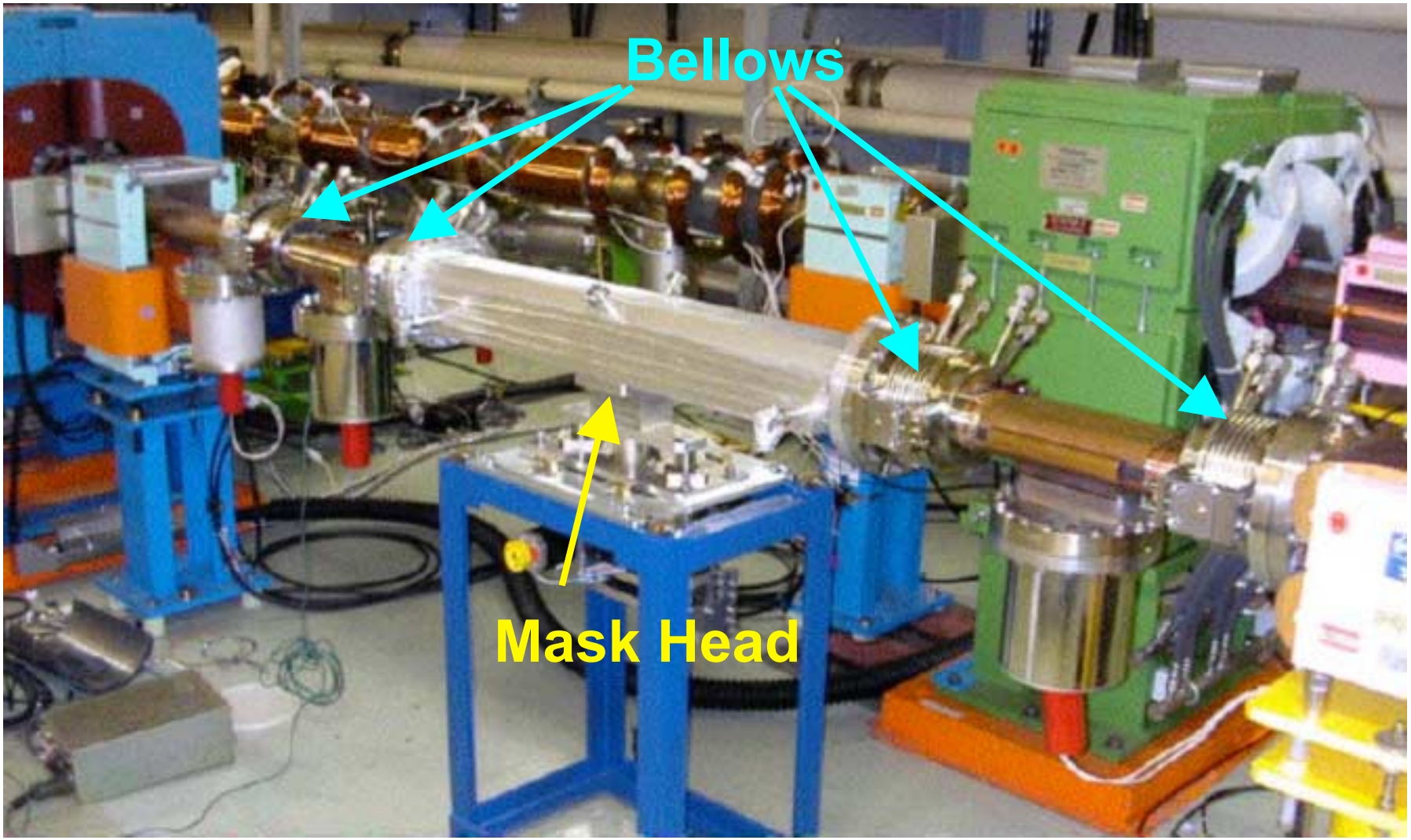
Previous Short Mask



New Long Mask



Movable Mask with Reduced HOM Design 3 - Picture



Movable Mask with Reduced HOM Design 4 – Loss Factor

- The loss factor of the V-Mask (HER) was estimated from MAFIA T3 simulation.

- $k(l=30\ \text{mm}) = 0.35$ [V/pC]

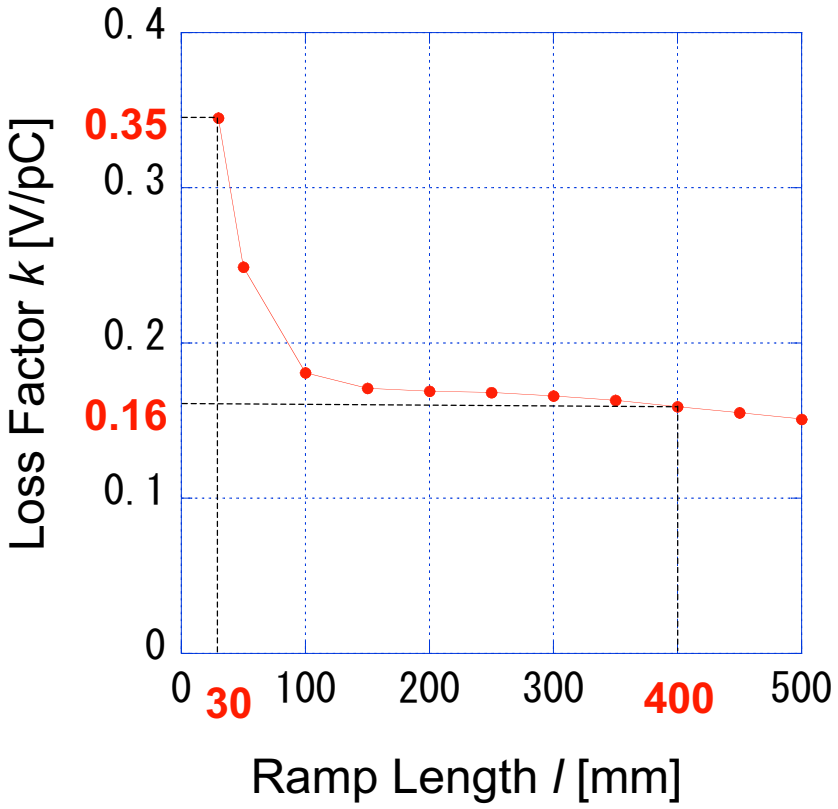
  $k(l=400\ \text{mm}) = 0.16$ [V/pC]

$$\frac{k(l=400\ \text{mm})}{k(l=30\ \text{mm})} \approx 0.5$$

Expectation from *k*:

The temperature rise of the bellows near the mask should reduce to 50 %.

Loss factor of the HER vertical mask as a function of the ramp length



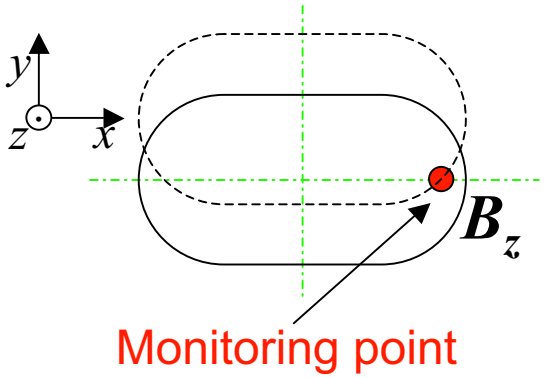
Movable Mask with Reduced HOM Design 5 – B_z^2

- B_z represents the TE-Mode HOM excited at the mask head.

  ⇩

  $\langle B_z^2 \rangle$ represents the power of the TE-Mode.

- $\langle B_z^2 \rangle$ was estimated from MAFIA simulation.



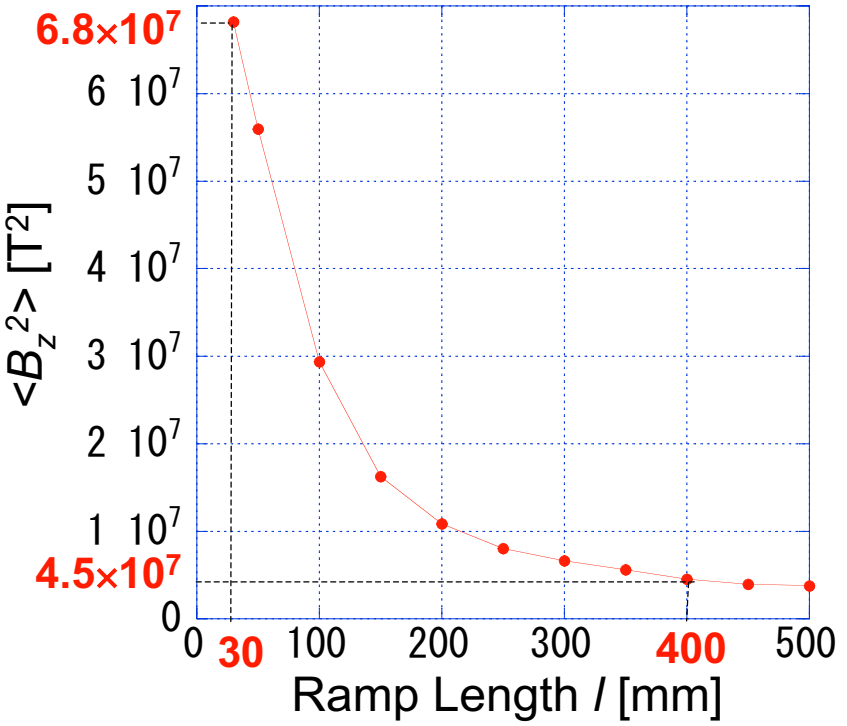
- $$\frac{\langle B_z^2(l=400\ \text{mm}) \rangle}{\langle B_z^2(l=30\ \text{mm}) \rangle} = \frac{4.5\times10^6}{6.8\times10^7}$$

  $$\approx 0.07$$

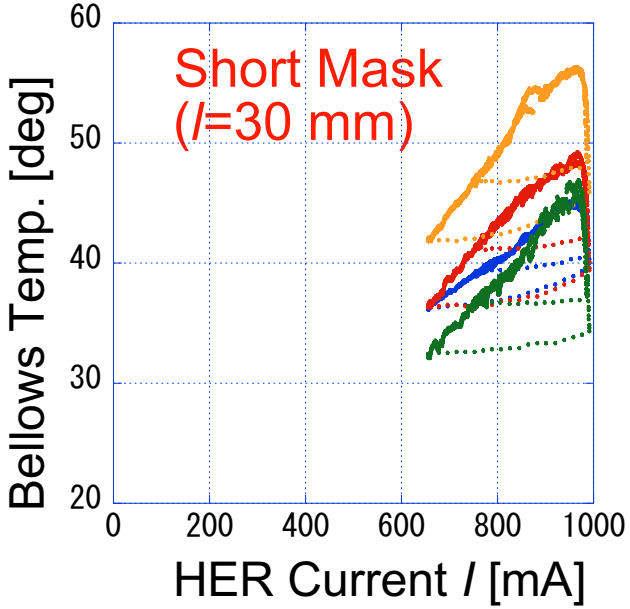
Expectation from B_z:

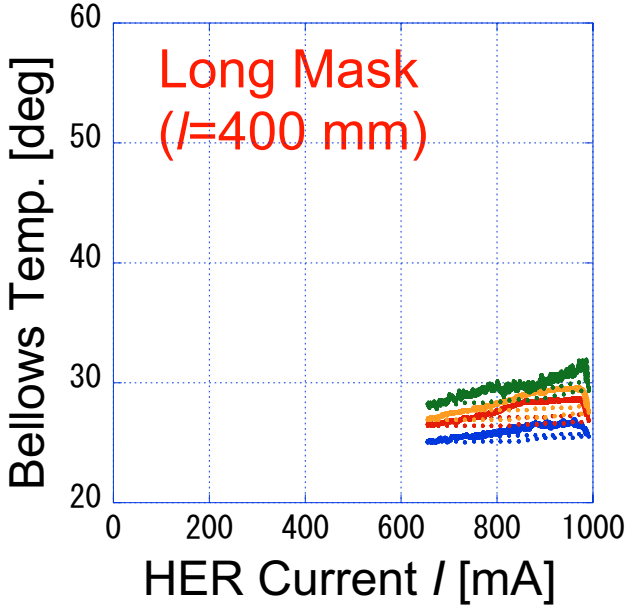
The temperature rise of the bellows near the mask could reduce to 7 %.

B_z^2 of the HER vertical mask as a function of the ramp length



Movable Mask with Reduced HOM Design 6 – Bellows Temperature





Behavior of bellows temperature against HER beam current

- $$\frac{\Delta T(l=400\ \mathrm{mm})}{\Delta T(l=30\ \mathrm{mm})} = \frac{4.3}{21.0} \approx 0.2 \quad (I=950\ \mathrm{mA})$$

Experimental result:

The temperature rise of the bellows near the mask reduced to 20 %.

Movable Mask with Reduced HOM Design 7 – Discussion

- There is a discrepancy between the expectation and the experimental result

Expectation from B_z		Experimental result		Expectation from k
$\frac{\langle B_z^2(400\text{ mm})\rangle}{\langle B_z^2(30\text{ mm})\rangle} = 0.07$	$<$	$\frac{\Delta T(400\text{ mm})}{\Delta T(30\text{ mm})} = 0.2$	$<$	$\frac{k(400\text{ mm})}{k(30\text{ mm})} = 0.5$
All of the TE-mode		Part of the TE-mode		Both the TE and TM mode

- The slit length is 20 mm

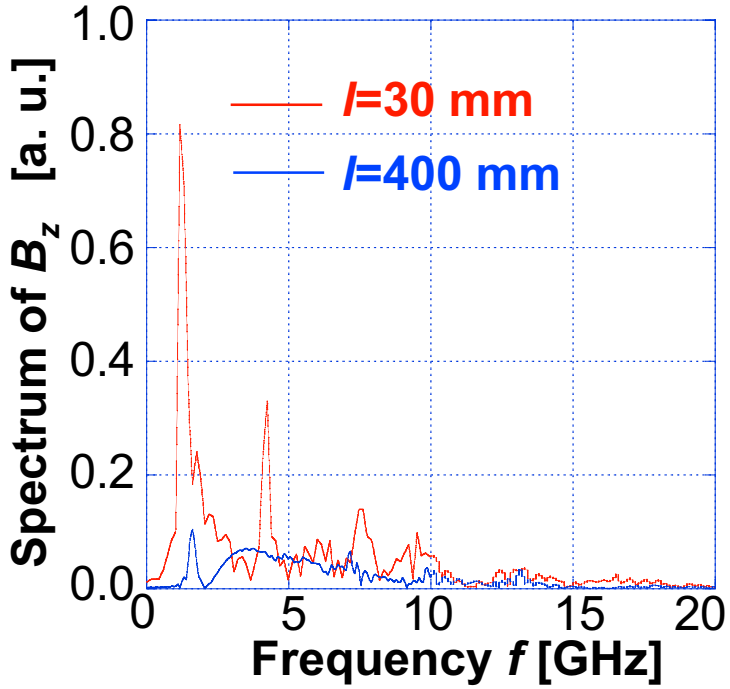
  ⇩

  The TE-Mode with low frequencies can not go through the RF shield of bellows.

  - For Example:

    f>2 [GHz] ⇨ $\frac{\langle B_z^2(400\text{ mm})\rangle}{\langle B_z^2(30\text{ mm})\rangle} \approx 0.2$

f > 2 GHz
Numerical result
||
Measured result



Spectrum of B_z for l=30 mm and l=400 mm for the HER V-Mask

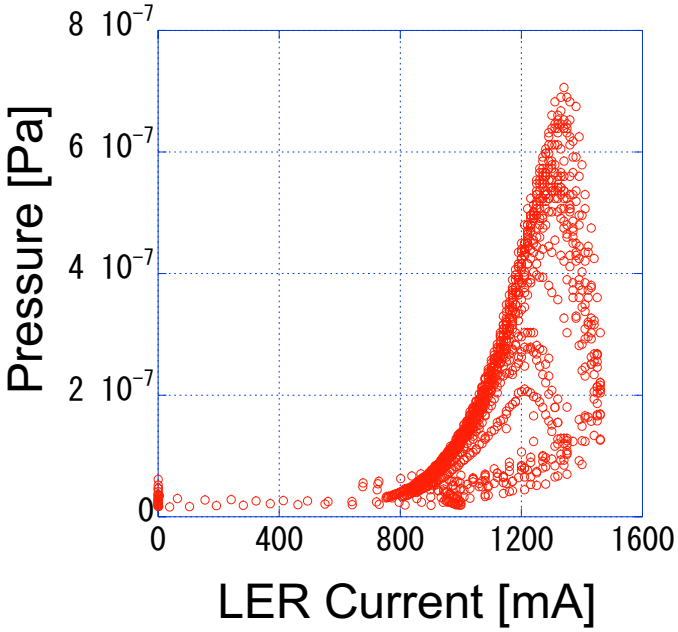
Winged HOM Damper 1 – Problem

- Abnormal pressure rise near the movable masks in LER (I>1200 mA)

Cause

- The TE-Mode HOM exited at the H-Mask went through the RF shield at the pumping port.
- The NEG element was heated and gas (H_2) was desorbed from the NEG element.

Behavior of pressure near the H-mask against beam current



- Installation of the special RF shield gasket
  - The HOM went to the outside of the shielded region.
  - Abnormal pressure rise at the outside of the shielded region was newly observed.
- Longer ramp of LER mask
  - LER mask : 130 mm
    HER mask : 30 mm

⇨ × Extension of the ramp of the mask

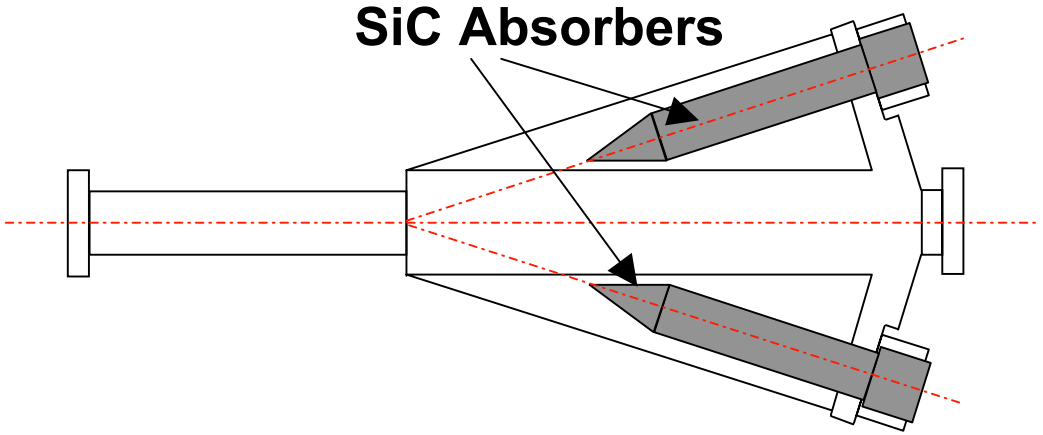
Countermeasure :

Development of the winged HOM damper

Winged HOM Damper 2 – Design

- Features
  - The damper has delta-type wings and two SiC absorbers are installed inside the both wings.
  - The wing and the beam chamber are connected with a long slot (20 mm wide ×707 mm long).

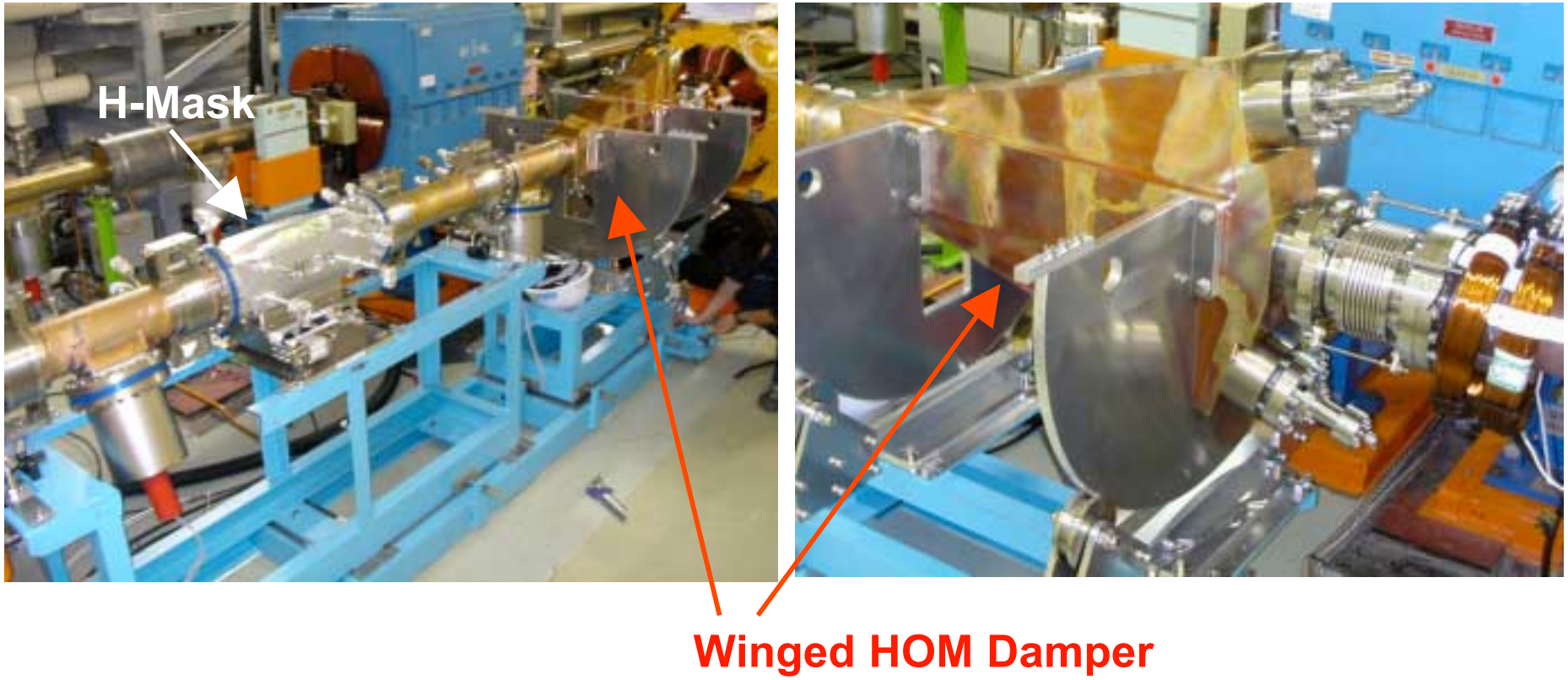
    ⇨ TE modes in a wide frequency range can be absorbed efficiently
  - The damping of the TE_{11} mode with a polarization perpendicular to the wing was about 12 dB for the frequency range from 2 to 6 GHz.



Winged HOM Damper

View from the Inside of the beam duct

Winged HOM Damper 3 – Pictures

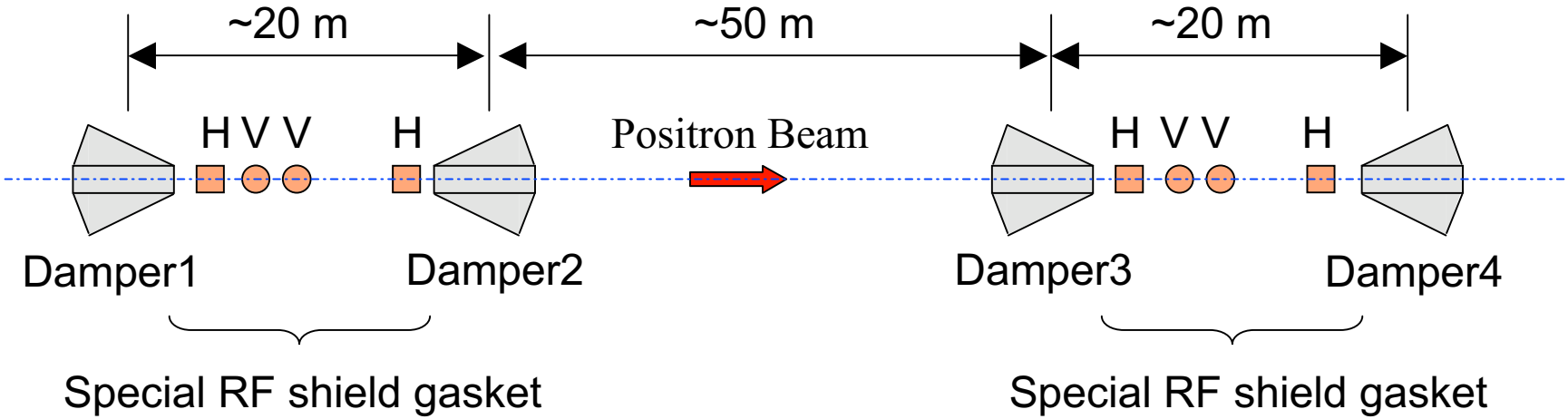


- The TE-Mode excited at the H-Mask is polarized horizontally.
- The TE-Mode polarized horizontally should go through the RF shield at the pumping port at the bottom of the beam duct.

⇒ The wing was placed vertically

Winged HOM Damper 4 – Installation

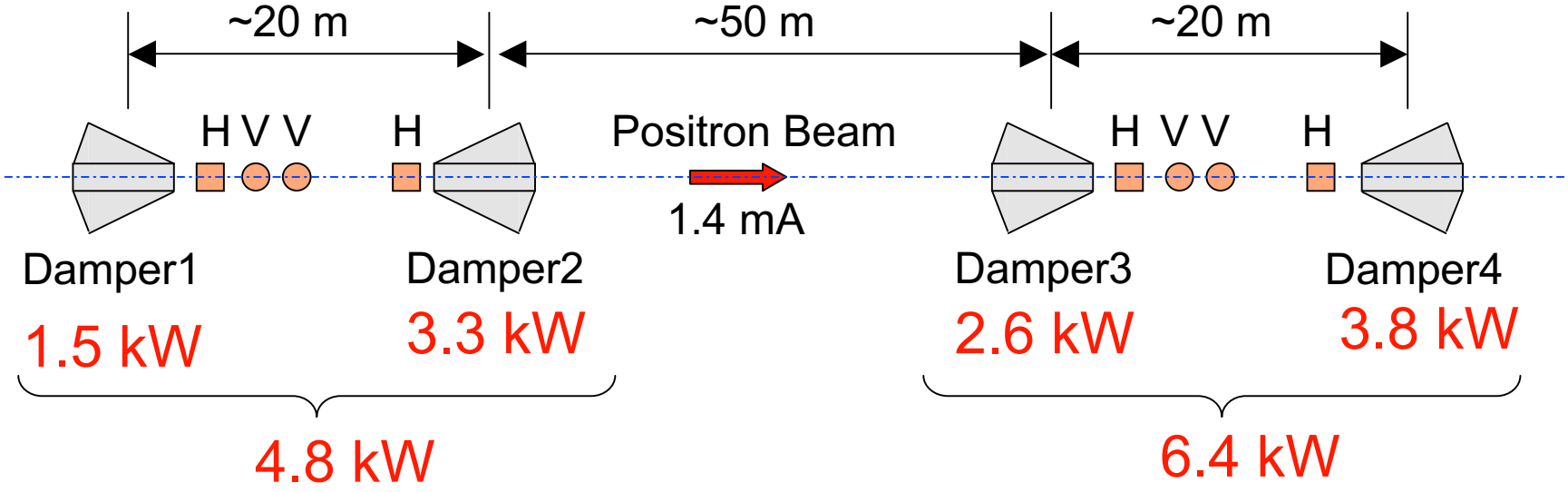
- Two pairs of the dampers were installed near the H-Mask in LER putting the four movable masks between each pair.
- To absorb the TE-Mode excited at the H-Mask, the wings were placed vertically and near the horizontal mask.
- Every pumping port between a pair of absorbers was screened by a special RF-shield gasket.



Winged HOM Damper 5 – Absorbed HOM power

- The absorbed HOM power was estimated from the temperature rise of the cooling water of the SiC absorbers.

Absorbed HOM Power



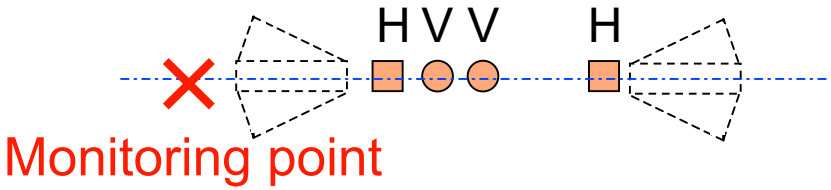
- Loss factor of H-Mask : 0.6 V/pC (for 10 mm gap)

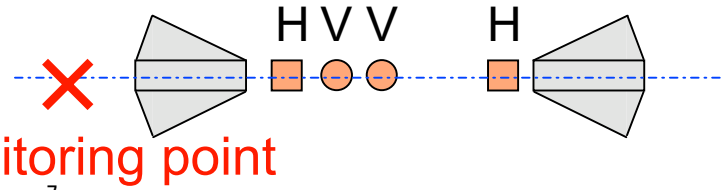
  ⟹ Power loss for two H-Masks : 20 kW (I=1.4 A)

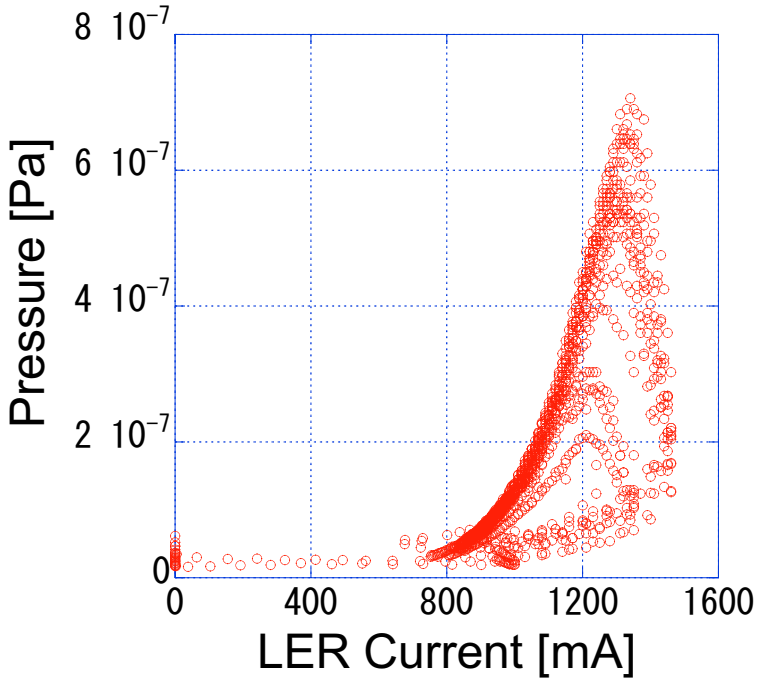
Absorption rate :

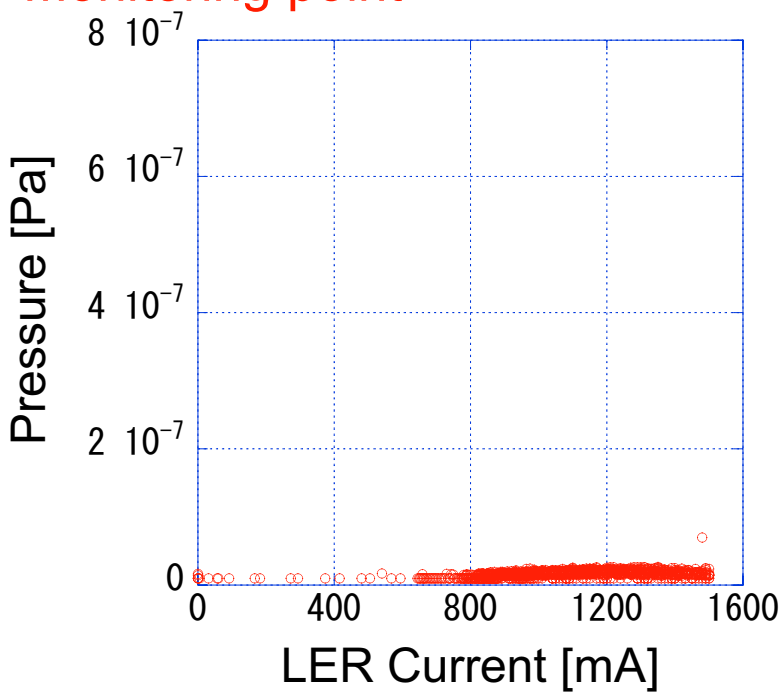
Damper1+Damper2	Damper3+Damper4
24%	32%

Winged HOM Damper 6 – Pressure near the masks









Behavior of pressure near the H-mask against beam current

Result :

The abnormal pressure rise near the mask disappeared at the outside of the HOM dampers.

Other improvements

- Change of the mask head

  Problem:
  - Groove generated on the mask head

  Countermeasure:
  - Change of the mask head material from Cu to Ti

  Result:
  - New groove was generated on 29/Jan./2003.
    (The beam energy was changed greatly by accident.)
  - We need more investigation.

- Remove of the IR movable mask

  Problem:
  - Heating of the components near the masks

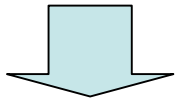
  Countermeasure:
  - Remove of the IR movable mask

  Result:
  - The temperature was reduced .

Summary and Conclusion

- Movable Mask with Reduced HOM Design
  - The ramps of the mask was expanded from 30 mm to 400 mm.
  - The temperature rise of the bellows near the mask reduced to 20%.

- Winged HOM Damper
  - The abnormal pressure rise near the mask disappeared outside the HOM dampers.
  - Detailed analysis is in progress.



Conclusion:

Both the movable mask with reduced HOM design and the winged HOM damper can relieve the heating of the components due to the TE-Mode.