Beam Collimators

KEKB Review
March 3rd, 2014
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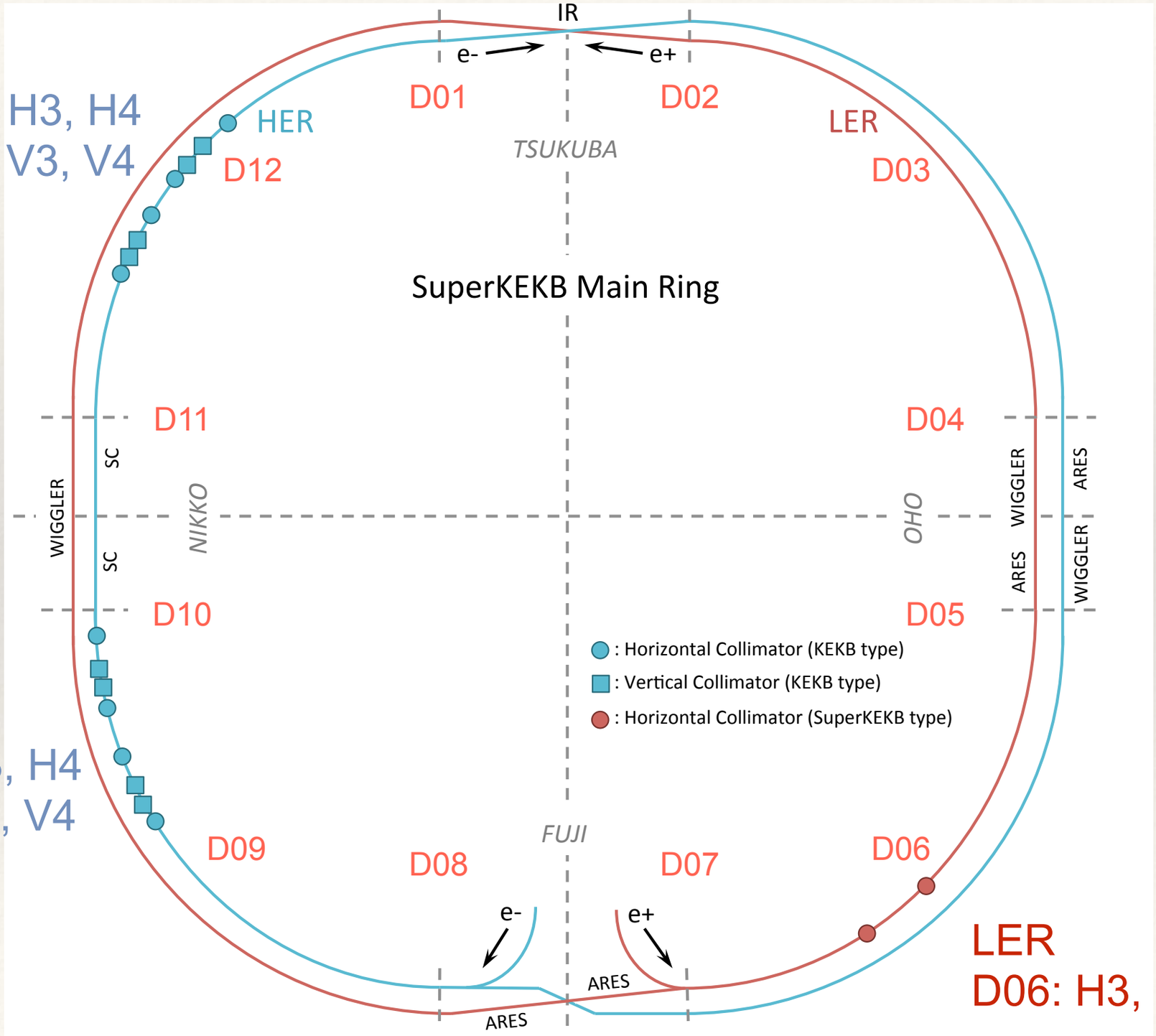
General

- We plan to install 10 horizontal and 3 vertical new type collimators in LER for SuperKEKB.
- In Phase-I, 2 horizontal collimators are going to be installed in an arc section of LER.
- A prototype of the horizontal collimator was manufactured.
- In HER, KEKB type collimators are going to be reused at the same locations as KEKB in the Phase-I stage.

Collimators Location (Phase-I)

HER
D12: H1, H2, H3, H4
V1, V2, V3, V4



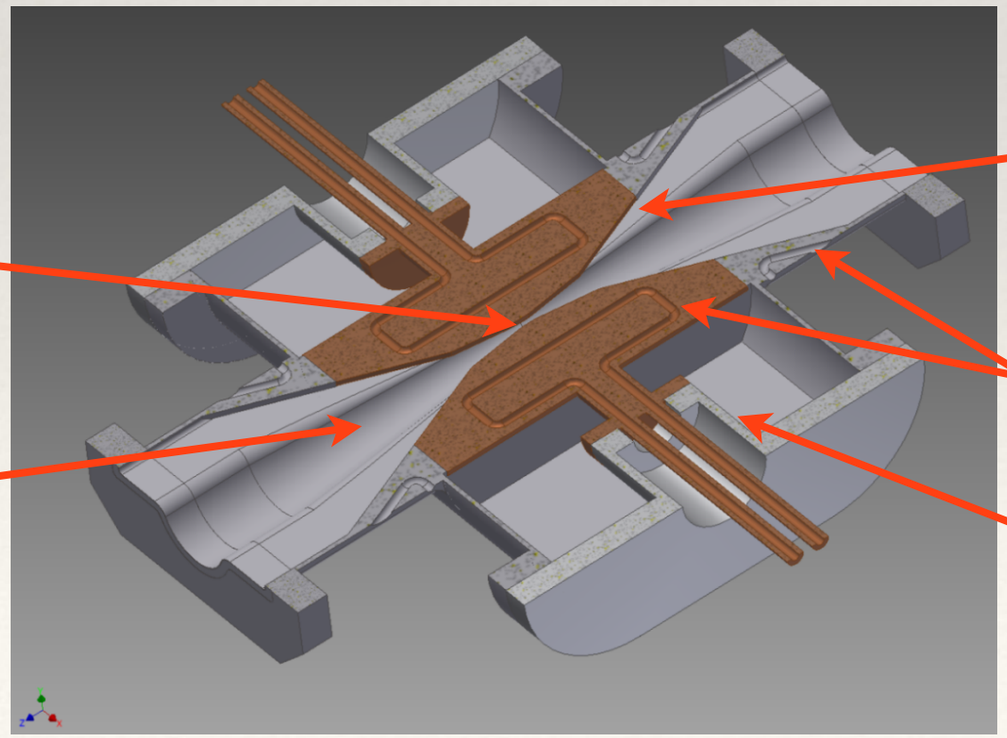
HER
D09: H1, H2, H3, H4
V1, V2, V3, V4

LER
D06: H3, H4

Basic Structure

- SLAC PEP-II collimators as a reference.
- The chamber and the heads are made from copper.
- The strokes of the movable heads are d=5-25 mm in horizontal and 2-12 mm in vertical.

  (“d” refers to the distance between the central beam axis and the tip of the head.)
- Tungsten is jointed at the tip of the head with Hot Isostatic Press(HIP, already succeed in the test).
- RF fingers are attached between the heads and chambers.

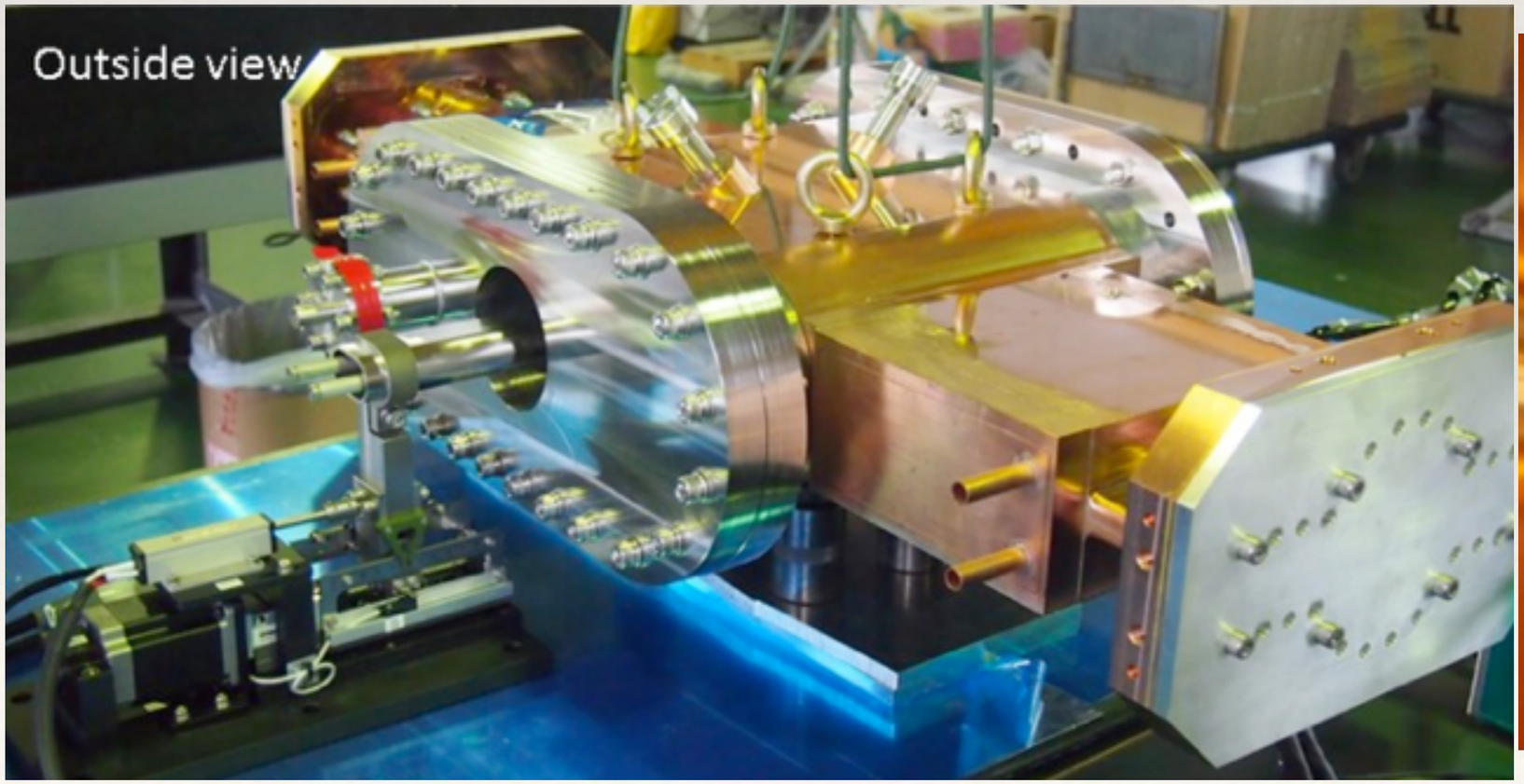


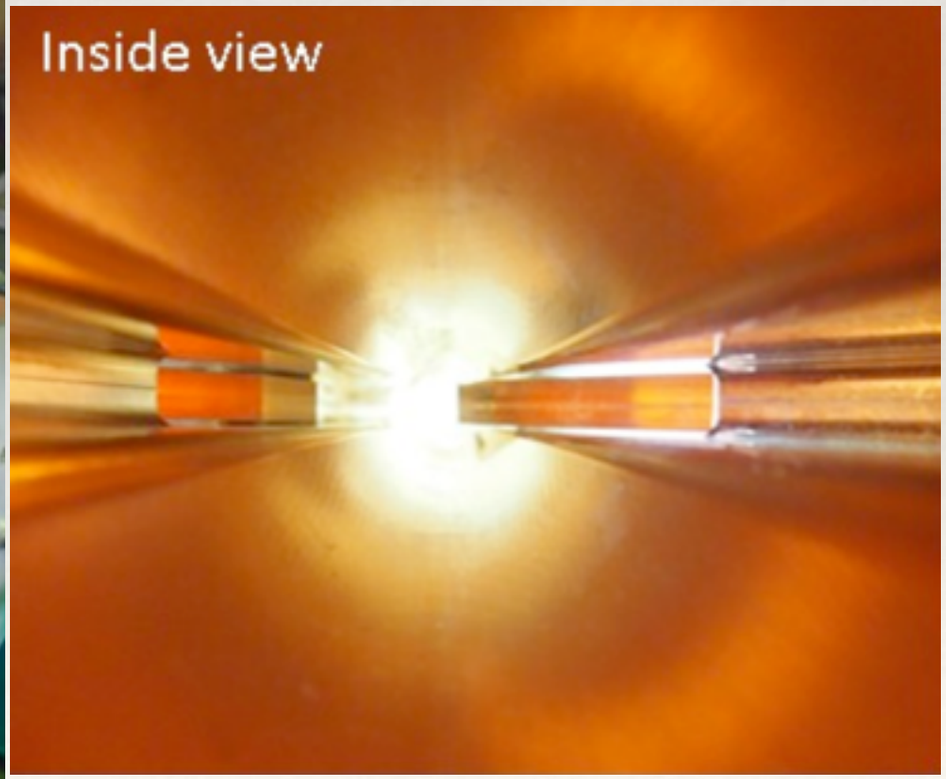
Mock-up of Head

- A mock-up of the movable head was manufactured.
- Tungsten, copper and stainless steel are jointed with HIP.

Prototype

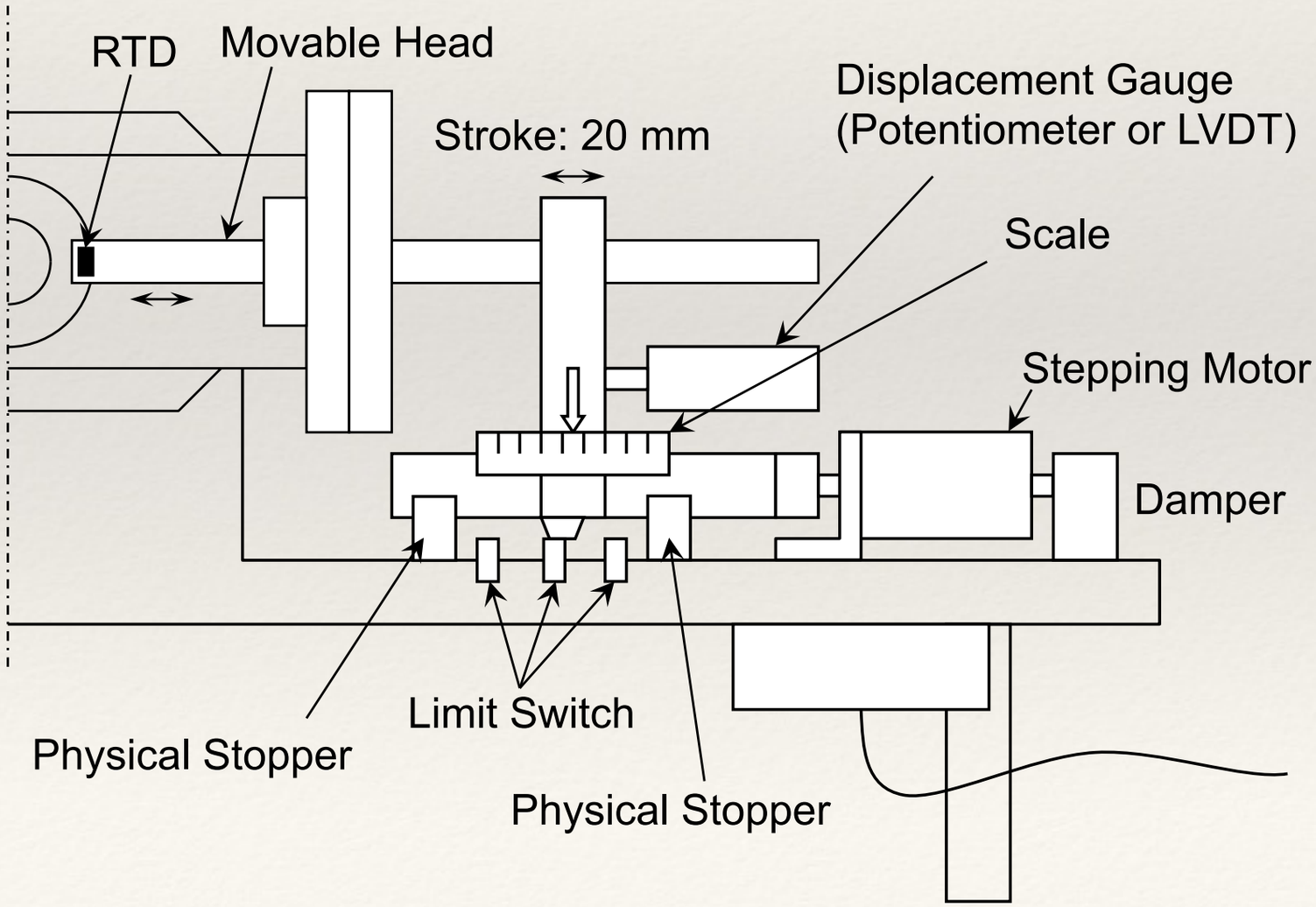
- A prototype of the SuperKEKB type horizontal collimator was manufactured.
- We've improved supports for the movable heads, RF fingers and so on through tests.





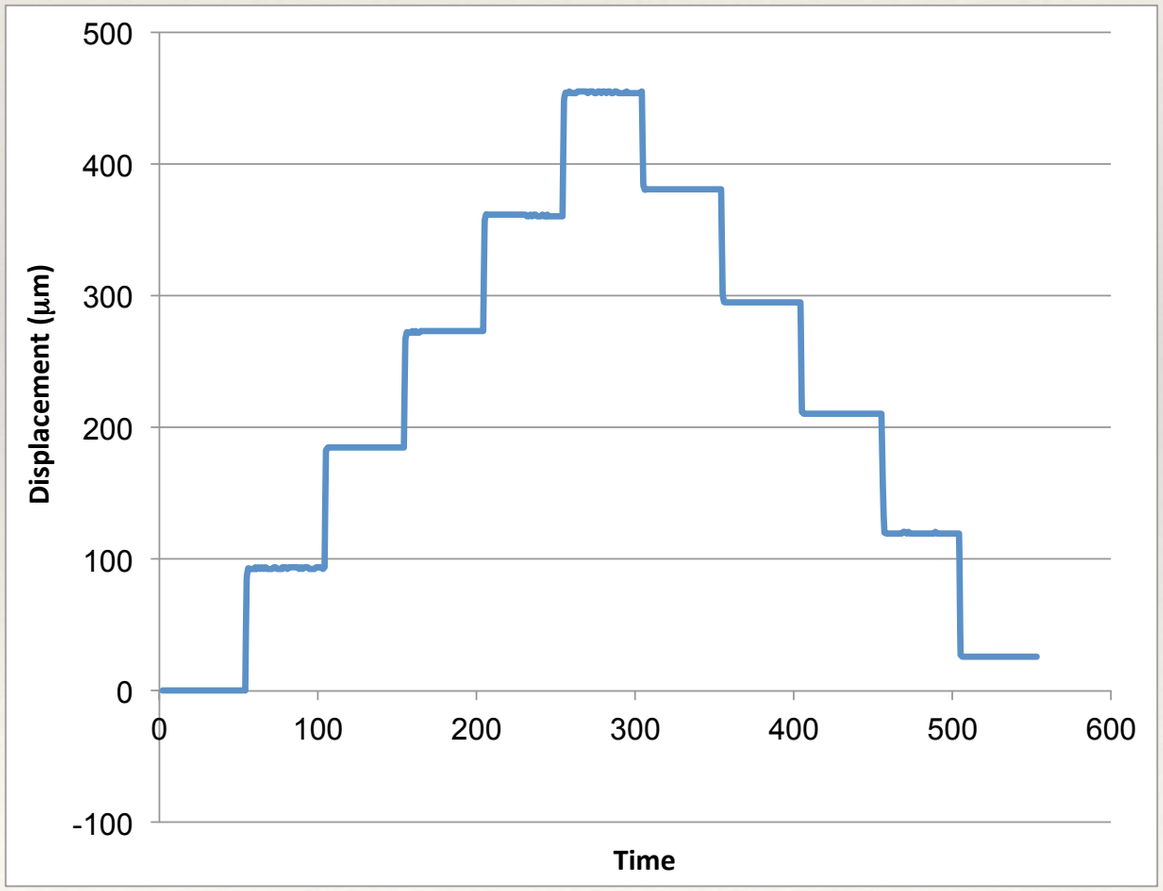
System Configuration

- 2-axis for a collimator
- 5-phase stepping motor with no backlash ball screw

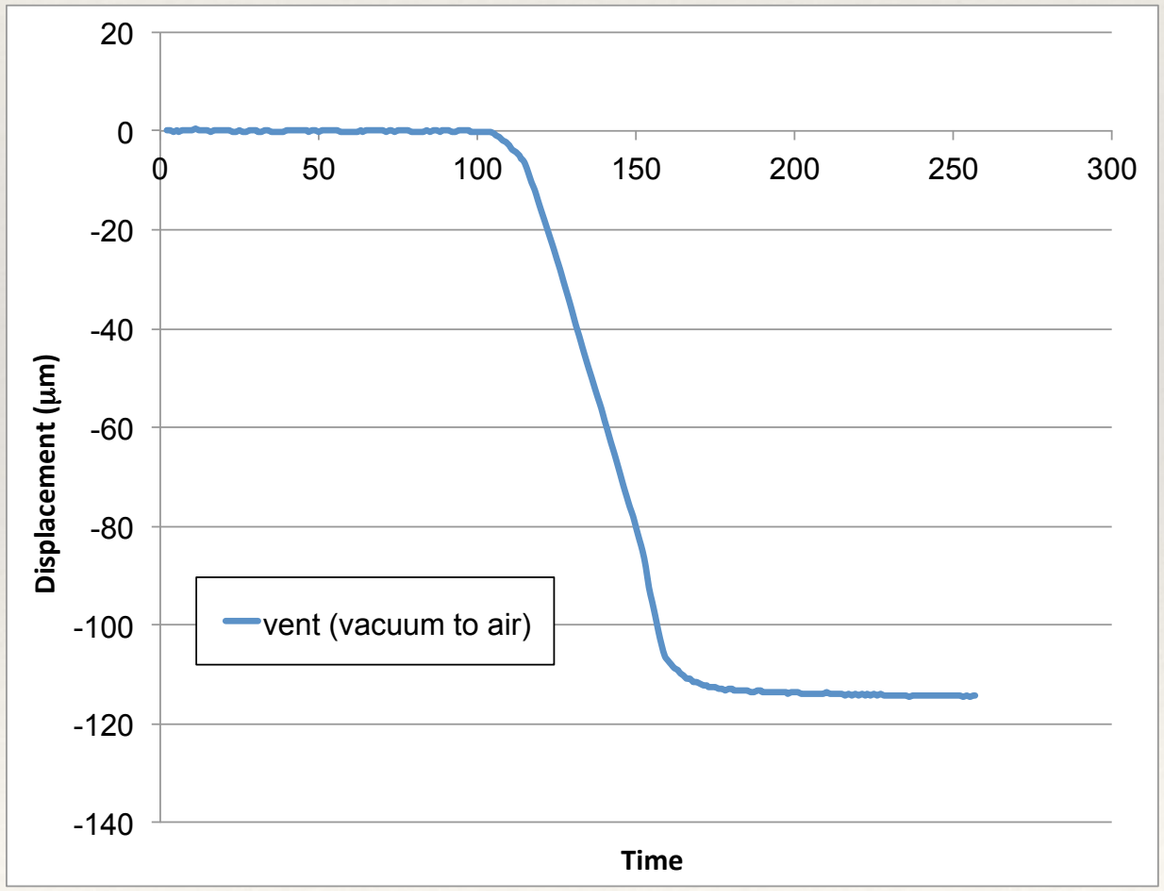


Displacement Measurement with LVDT

- In vacuum
- positioning accuracy without feedback: ~±25 μm
- We try to put the motor axis on the same axis of the movable head to minimize the deflection at the support, but there is a limitation to the width.



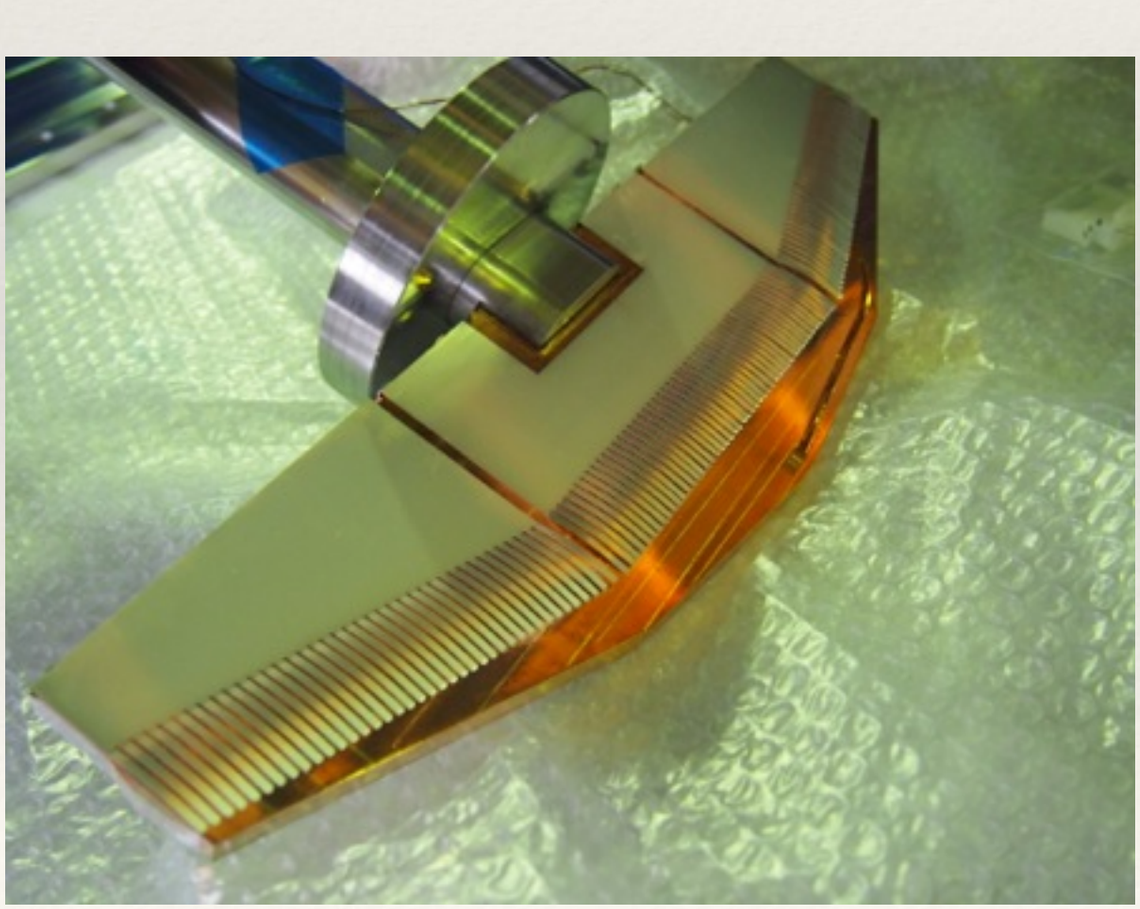
300 pulses/step



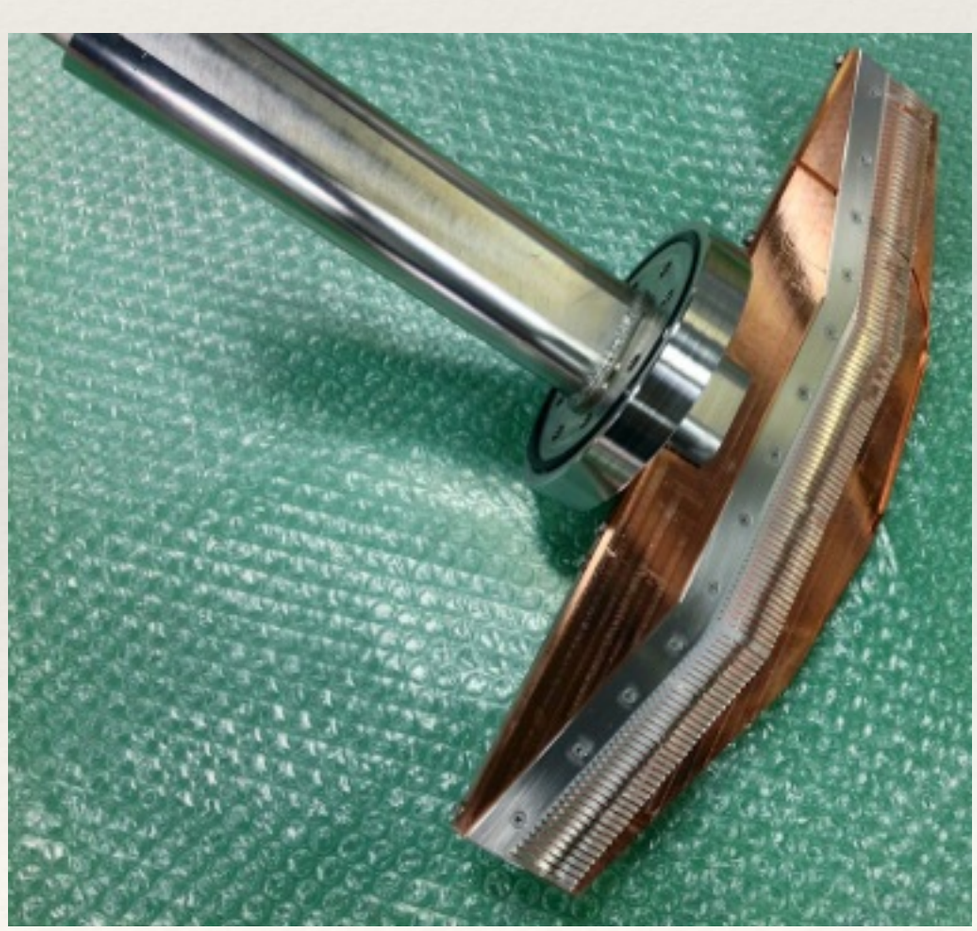
vent

RF Fingers

- The base material is INCONEL, which is also used for RF fingers of bellows chambers in KEKB.
- A comb-type RF shield would be adopted at the longitudinal side of the head.



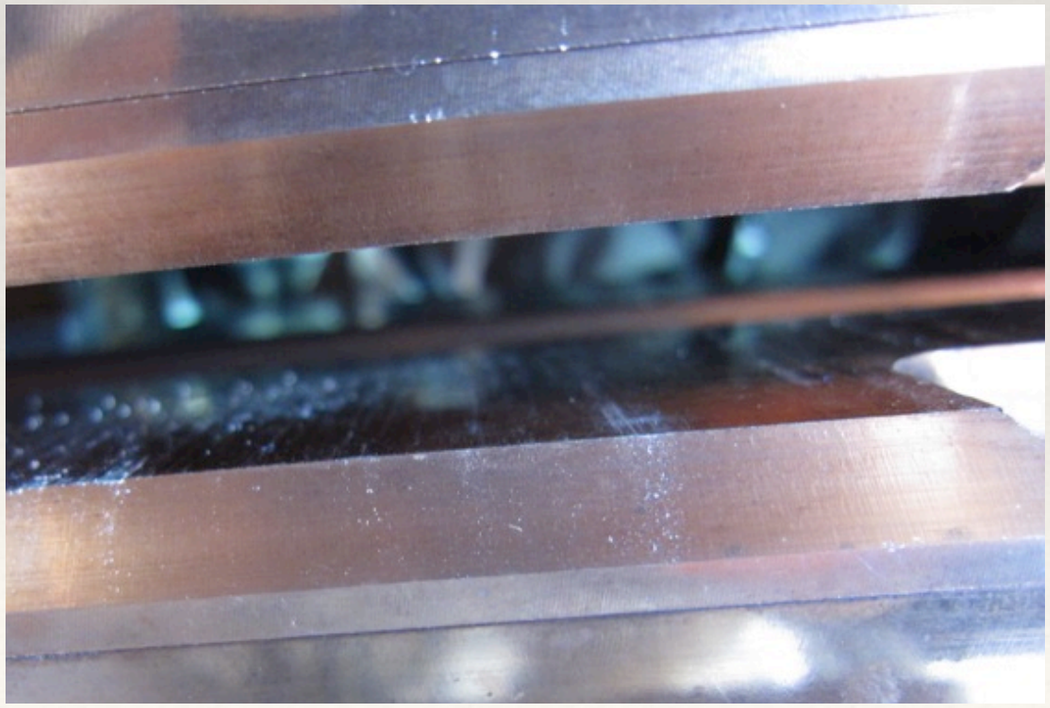
Silver plated RF fingers (ver.1)



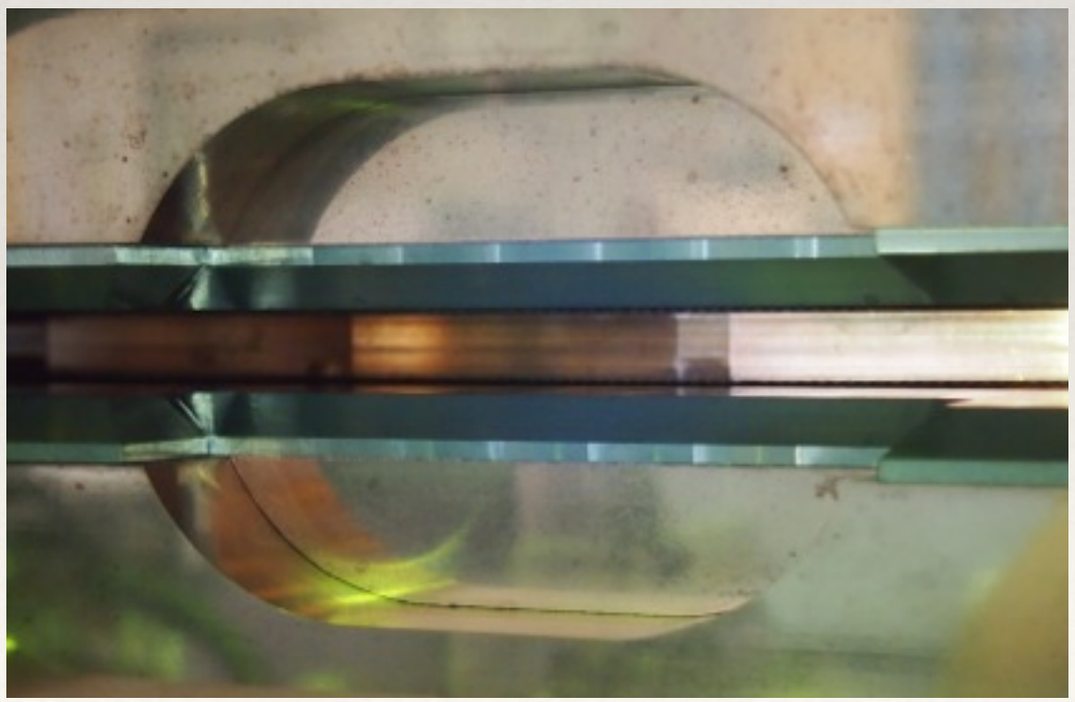
Silver plated RF fingers (ver.2)

Long-duration Test

- shuttle the head back and forth for about 100 hours repeatedly.
- stroke: 12 mm, velocity: 2 mm/s
- total distance of the movement in the test: ~720 m



Copper surface

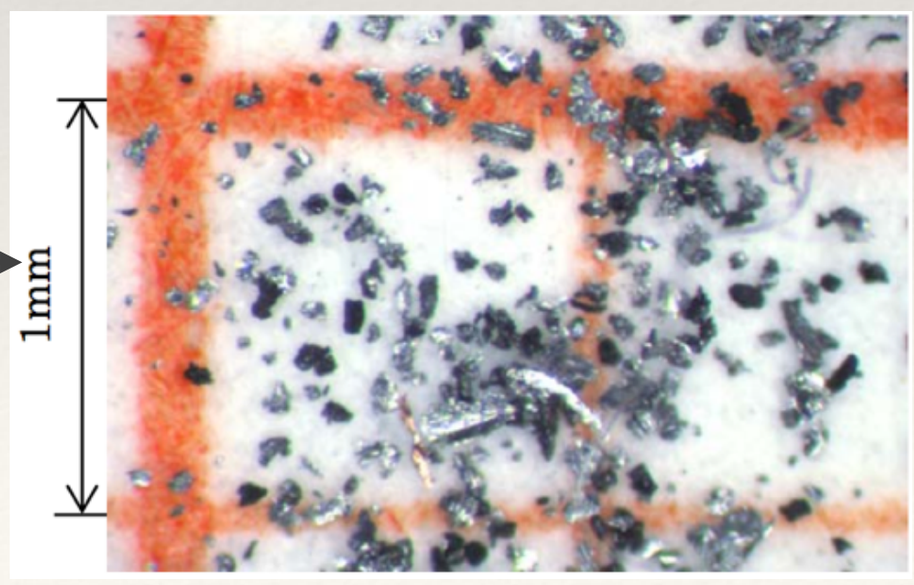


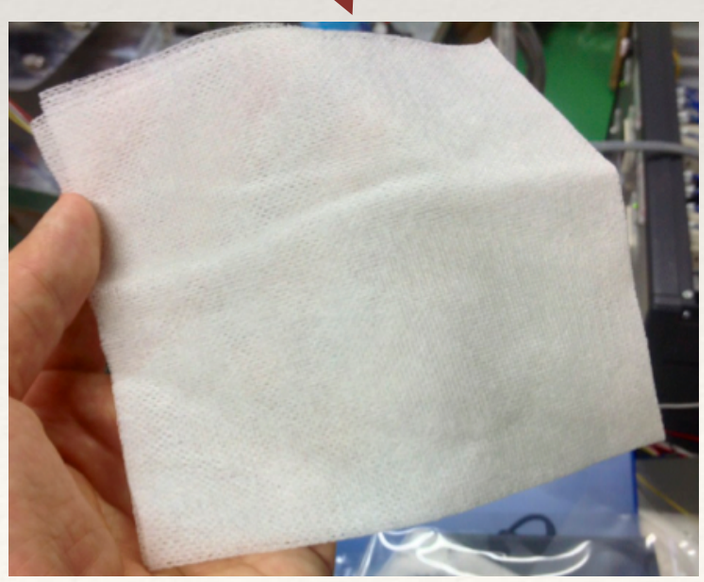
Stainless surface

Long-duration Test

- We’ve adopted the silver plated INCONEL for the RF fingers and the stainless steel for the contact surface.
- It still generates dusts, so we continue to seek a better combination.

\RF Fingers Contact Surface\	INCONEL	Rhodium plated INCONEL	Silver plated INCONEL
Copper	NG (soft contact surface)	NG (soft contact surface)	NG (soft contact surface)
Stainless	NG (too much SS dusts)	NG (too much SS dusts)	OK (small Ag dusts)

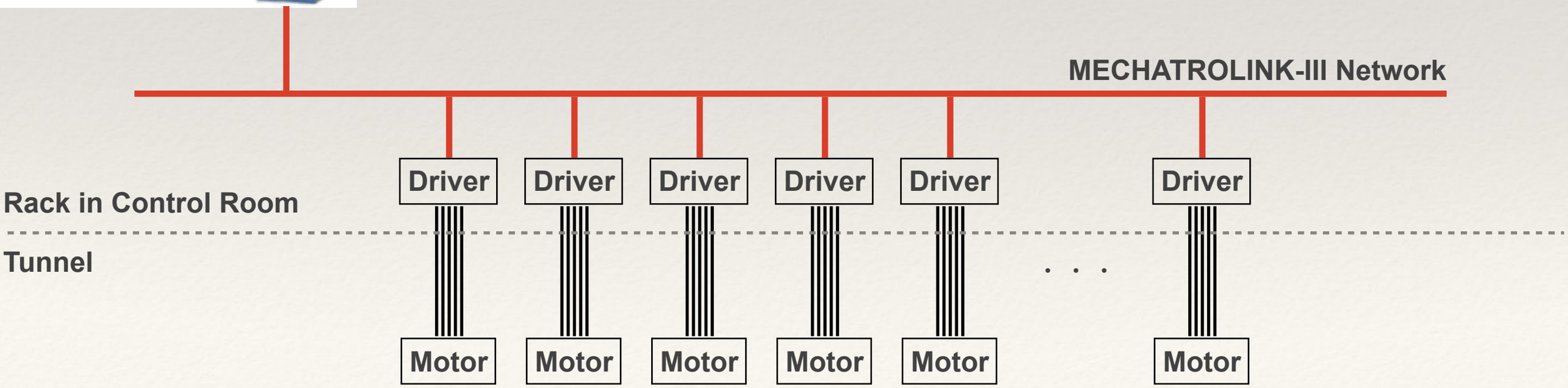




Control System

- We would adopt a MECHATROLINK-III system in which a PLC module controls multi-devices.

  - F3NC07-0N (YOKOGAWA)
  - Max. 15-axis control with a module
  - Communication rate: 100 Mbps
  - Communication cycle: 0.25 ms/4-axis, 0.5 ms/8-axis, 1.0 ms/15-axis



Summary and Future Plans

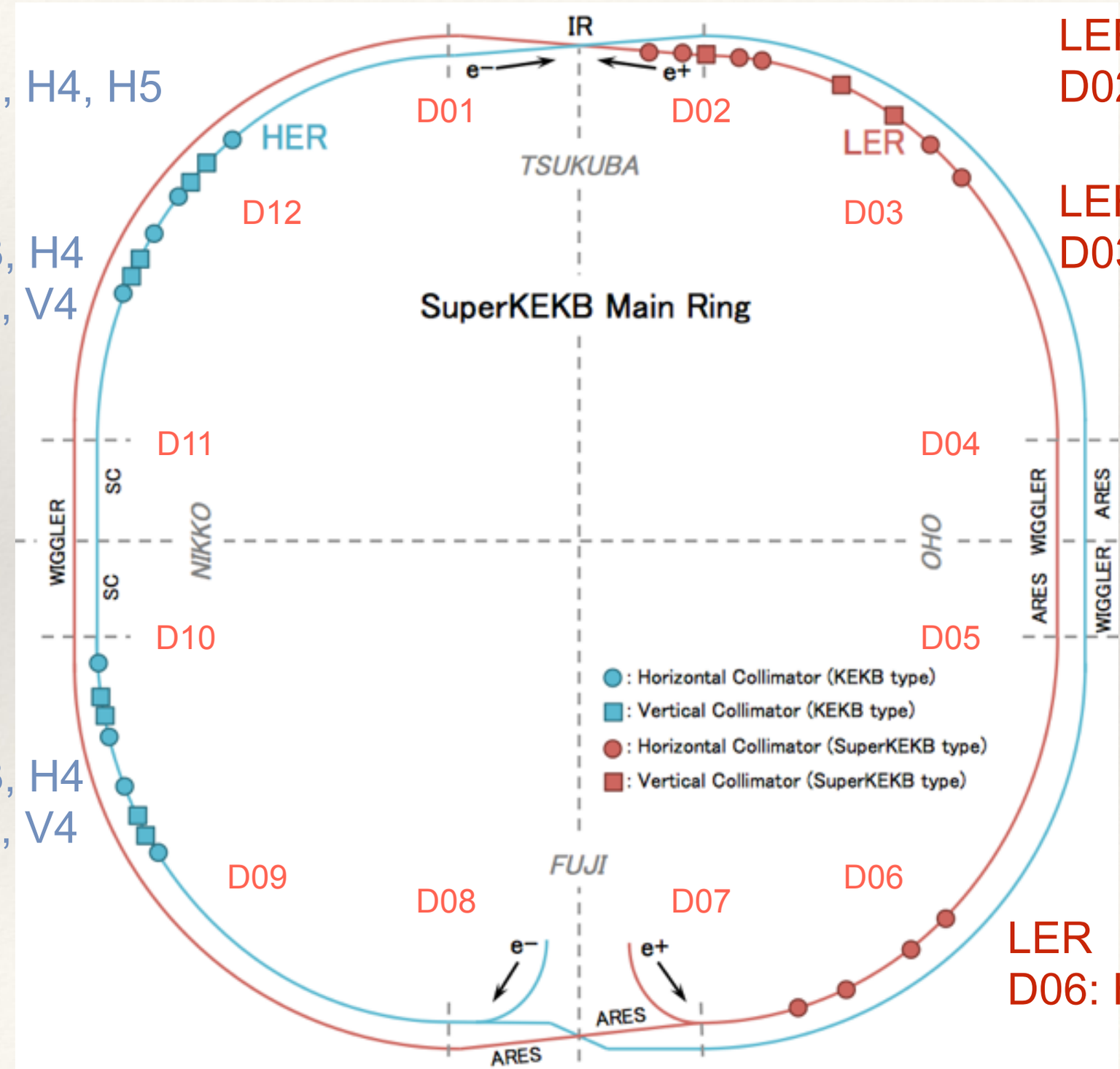
- We’ve developed a new type collimator for SuperKEKB.
- A prototype of the SuperKEKB type horizontal collimator has been manufactured, and we‘ve improved the structural problems through tests.
- We’ve adopted a silver plated INCONEL for RF fingers and a stainless steel for the contact surface so far.
- It still has an issue about long-term durability and dust generations.
- We plan to build and install two horizontal collimators in LER by Phase-I commissioning.
- We have to study a radiation shield at the collimators.

back-up

Collimators Location (Phase-II)

HER
D01: H1, H2, H3, H4, H5
V1

HER
D12: H1, H2, H3, H4
V1, V2, V3, V4



LER
D02: H1, H2, H3, H4
V1

LER
D03: H1, H2
V1, V2

HER
D09: H1, H2, H3, H4
V1, V2, V3, V4

LER
D06: H1, H2, H3, H4

TMCI

- We estimated the threshold of the Transverse Mode Coupling Instability using actual β value at each collimator with σ_z = 6 mm.
- The bunch current of the design value in LER is 1.44 mA/bunch.
- A kick factor in D02V1 is quite large because of the narrow aperture (±2 mm), and it limits the bunch current.
- We may need an another structure, such as long heads with gradual slope, for D02V1.

	TMC Threshold (mA/bunch)	
	All Closed	Actual Apertures
Horizontal	1.41	13.15
Vertical	0.96	1.25

$$I_{thresh} = \frac{C_1 f_s E/e}{\sum_i \beta_i \kappa_{\perp i}(\sigma_z)}$$

Collimator and Aperture List

D06H1	-16.0/+17.0	D03H1	-21.0/+20.0	D02H1	-10.6/+12.0
D06H2	-16.0/+16.0	D03H2	-18.0/+20.0	D02H2	-16.0/+20.0
D06H3	-16.0/+15.0	D03V1	-9.0/+9.0	D02H3	-18.0/+21.0
D06H4	-13.0/+13.0	D03V2	-9.0/+9.0	D02H4	-13.0/+9.0
	(mm)		(mm)	D02V1	-2.0/+2.0