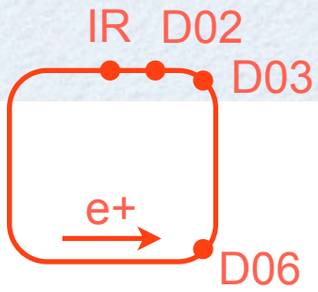
Progress of SuperKEKB Collimator

The 18th KEKB Accelerator Review Committee
March 4th, 2013
Takuya Ishibashi (on behalf of KEKB Vacuum Group)

General Info

- We plan to install 10 horizontal and 3 vertical SuperKEKB type collimators in LER.
- At the beginning of the commissioning, 2 horizontal collimators are going to be installed in LER.
- In HER, KEKB type collimators are going to be reused at the same locations as KEKB at the beginning.
- We plan to renew all of the KEKB type collimators in HER in the future.



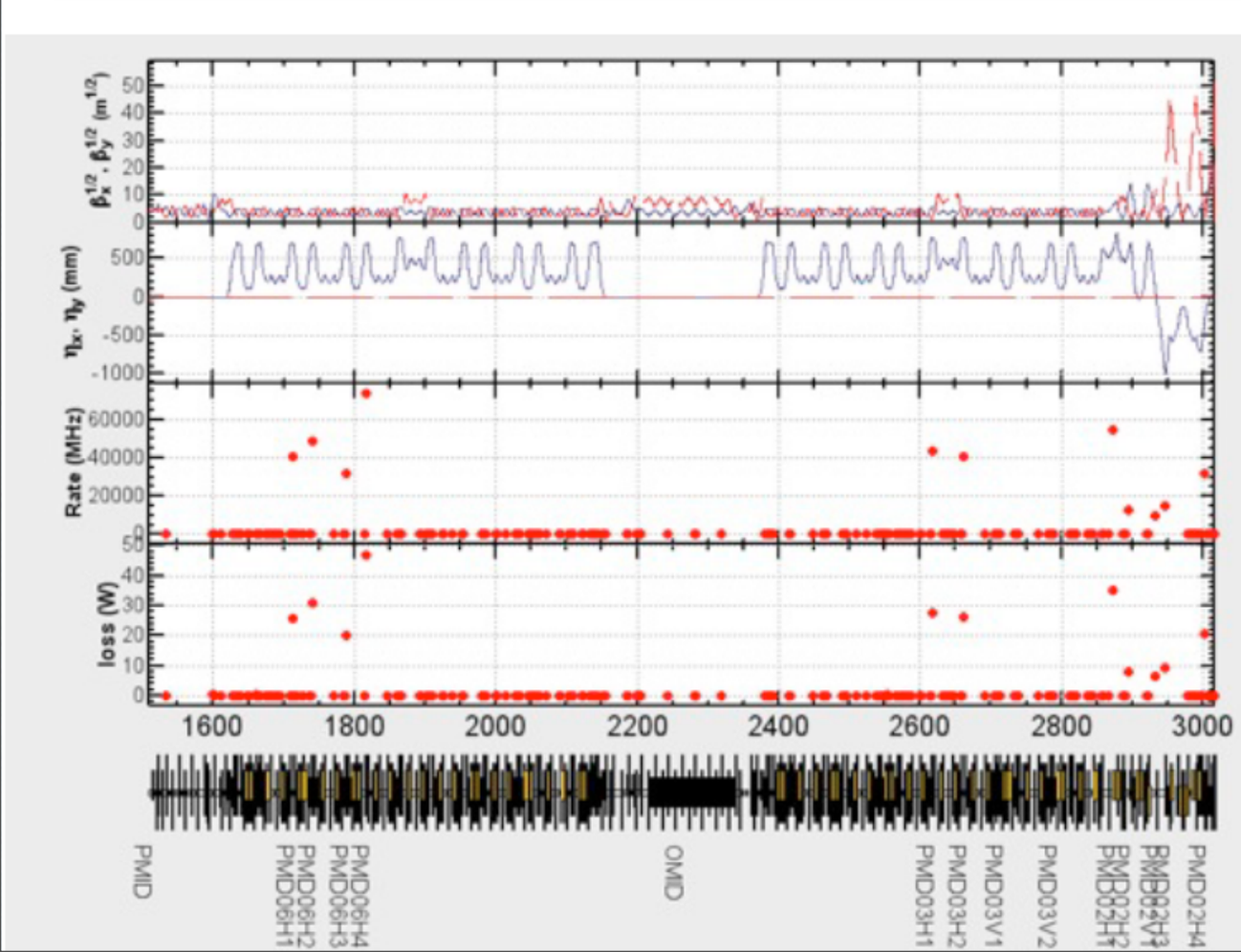
by Y. Ohnishi

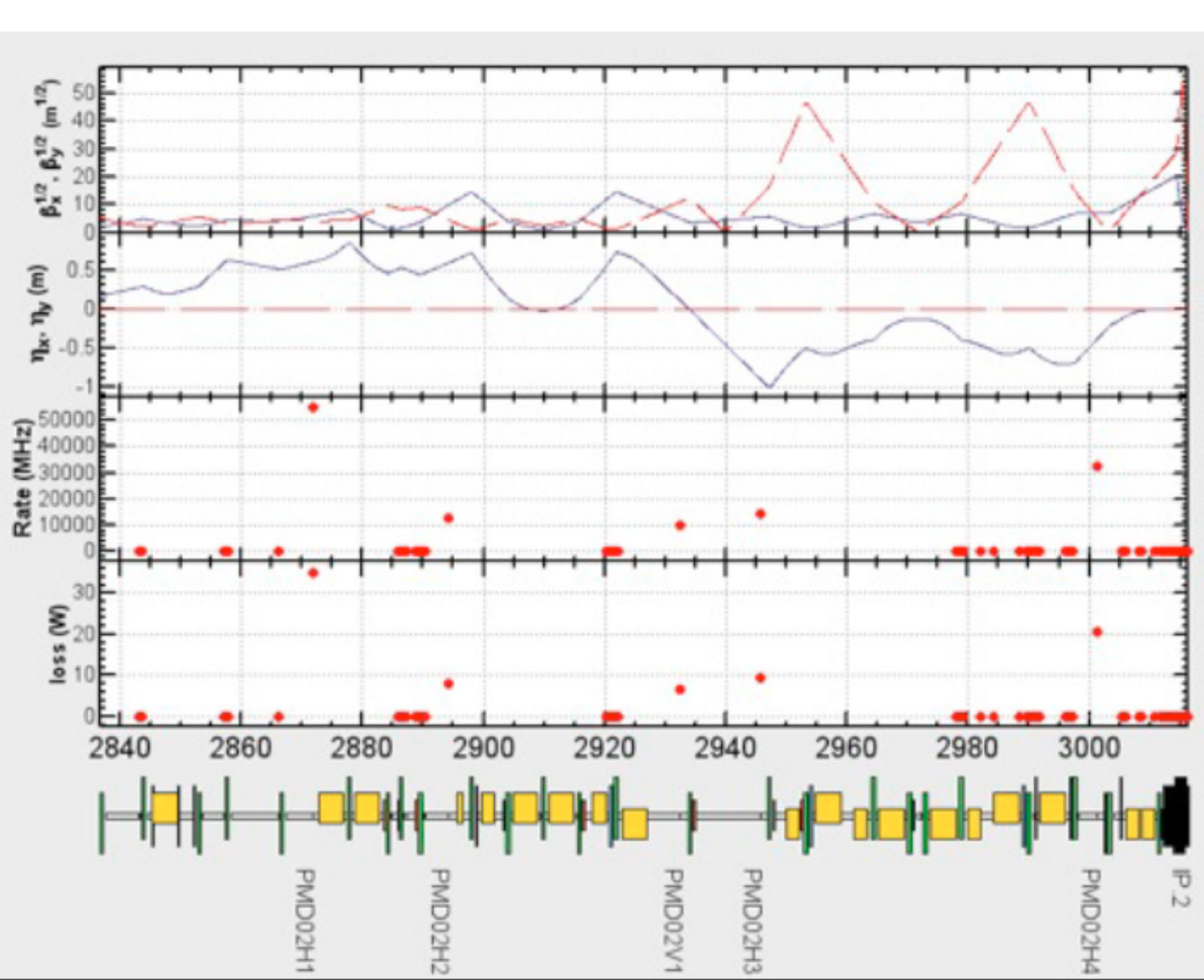
LER: Touschek Background

sler_1672_5

LER_2012_06_22_11:26

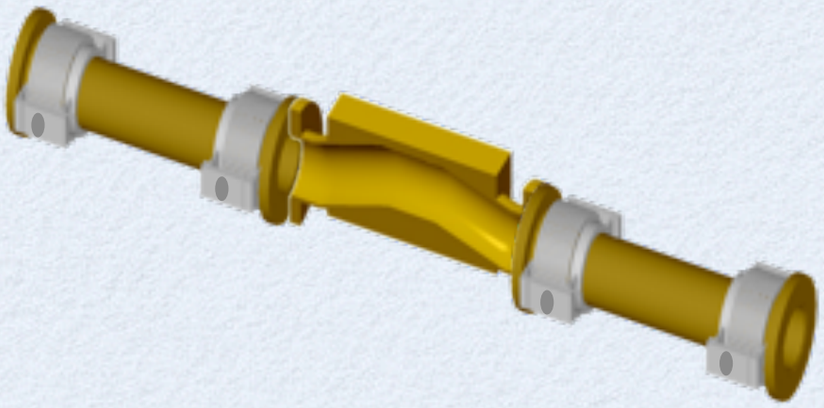
D06H1	-16.0/+17.0	D03H1	-21.0/+20.0	D02H1	-10.6/+12.0
D06H2	-16.0/+16.0	D03H2	-18.0/+20.0	D02H2	-16.0/+20.0
D06H3	-16.0/+15.0	D03V1	-9.0/+9.0	D02H3	-18.0/+21.0
D06H4	-13.0/+13.0	D03V2	-9.0/+9.0	D02H4	-13.0/+9.0
	(mm)		(mm)	D02V1	-2.0/+2.0



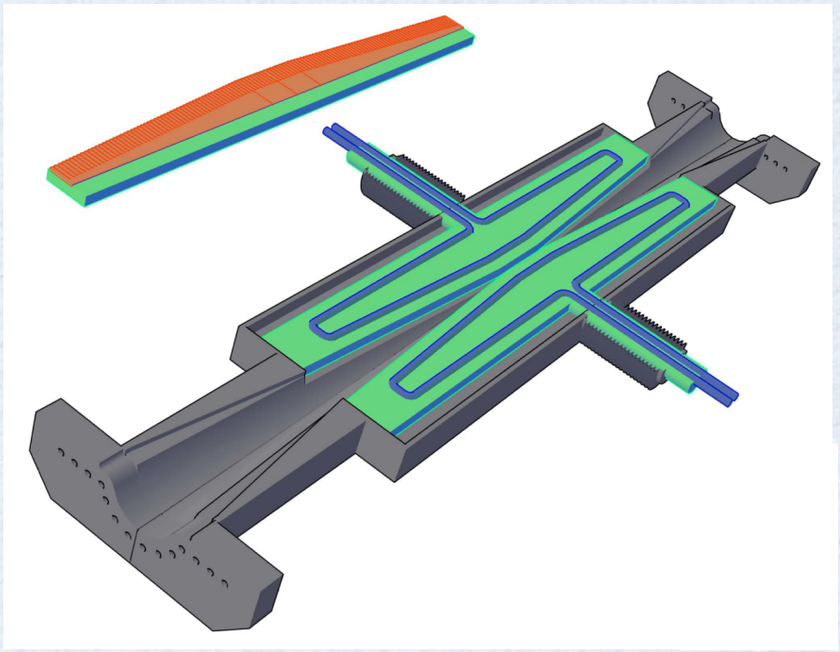


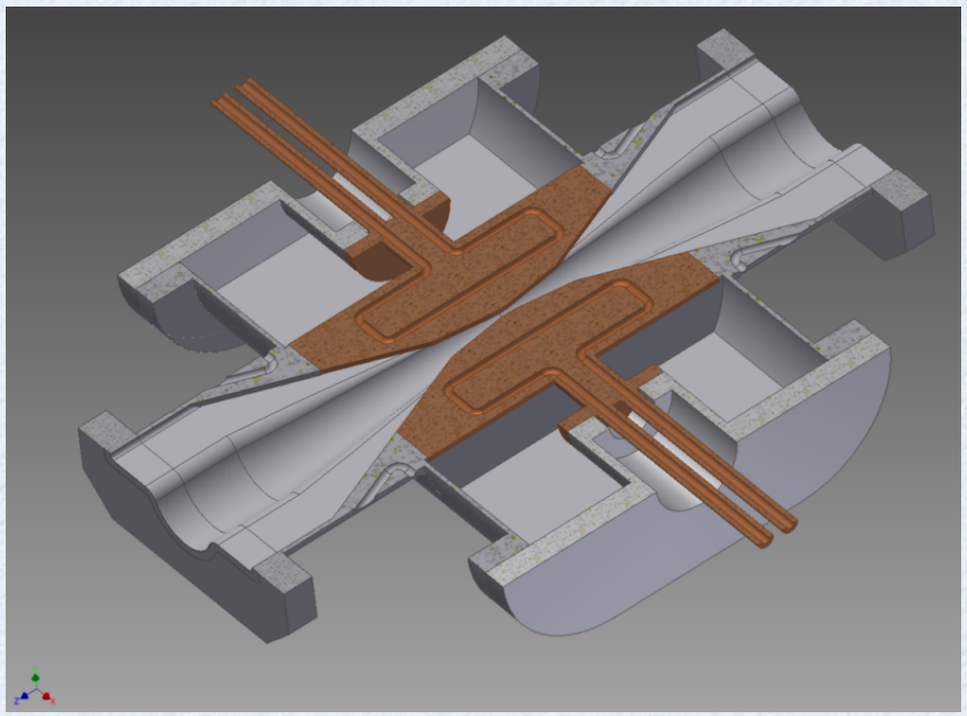
Collimator's History

Ver.4: KEKB type



Ver.5: Fit antechambers. The loss factor is smaller by a factor of 2 compared with Ver.4. Total length ~1500 mm.





Ver.6: The latest version. Part of the movable heads are placed in the antechambers. The total length is shorten with the same loss factor as Ver.5.
Total length ~ 1000 mm.

Design Concepts of Ver.6

- Part of the movable heads is hidden inside the antechambers to reduce the impedance and increase maintainability by downsizing the collimators.
- Need to get space for installations of HOM absorbers and bellows up/downstream of the collimators by the downsizing.
- Have to avoid the trapped-modes.

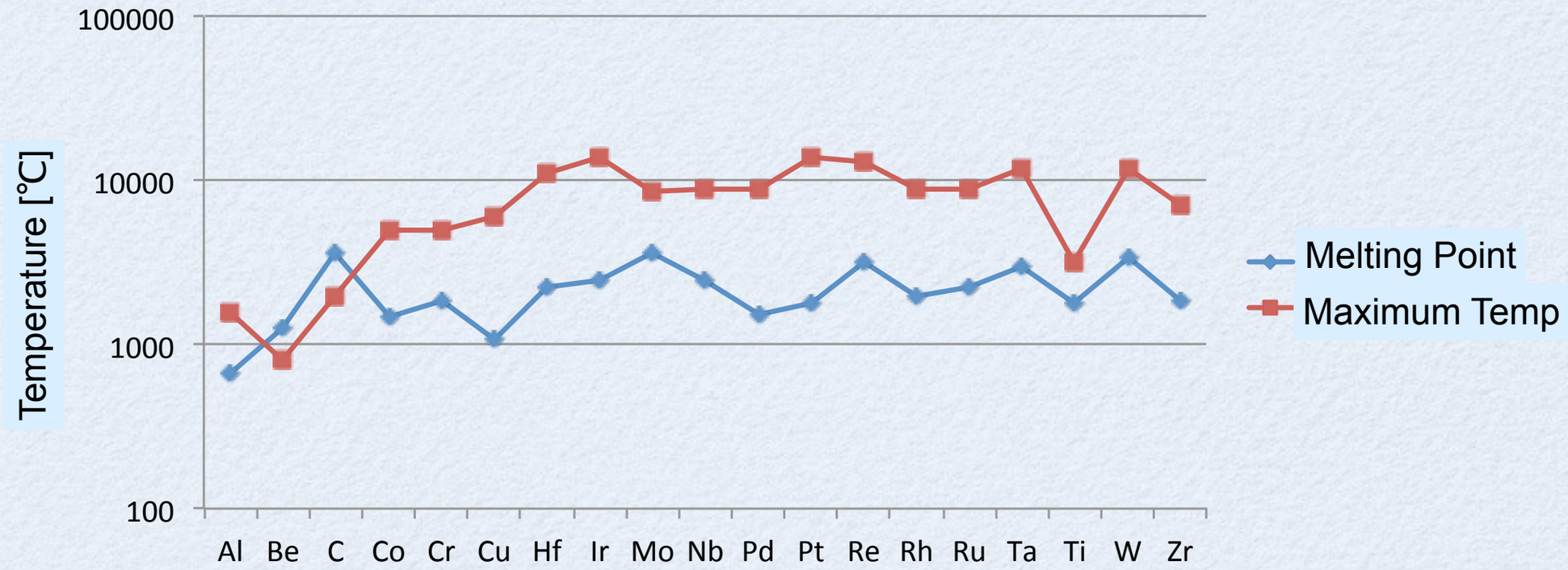
SR Power Estimation

- In the collimator location, the power density at a vertical wall is about 19.3 kW/m, and this is approximately-same as that at a wiggler region of LER.
- When the ramp's angle of the wall becomes 30 degrees, the power density is about 9.7 kW/m.
- This would be no problem for Copper wall with cooling water.

Material for the Tip

- If all bunches in the ring hit the movable head, all materials that we investigated would melt.
- Materials which have narrow gap between the melting point and the maximum temperature: Be, C, Cr, Mo, Ti, W
- We’ve adopted tungsten because of the availability, the junction property with copper, the electric and thermal conductivity.

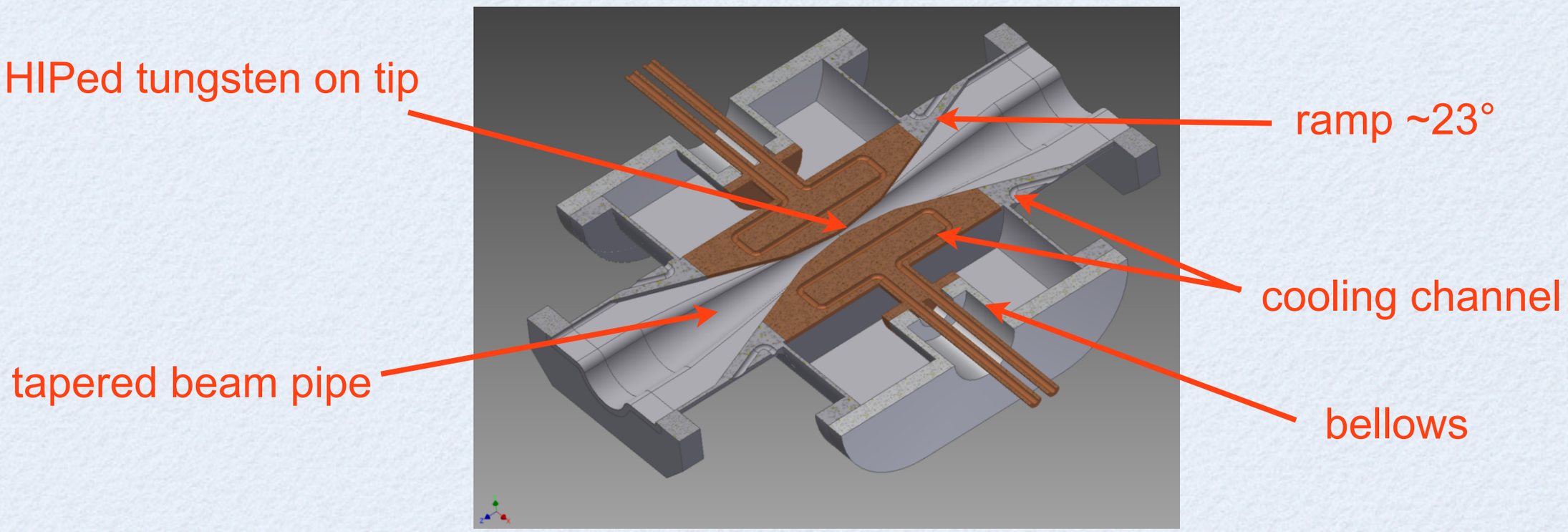
→ enable easy replacement of the movable head



Structure

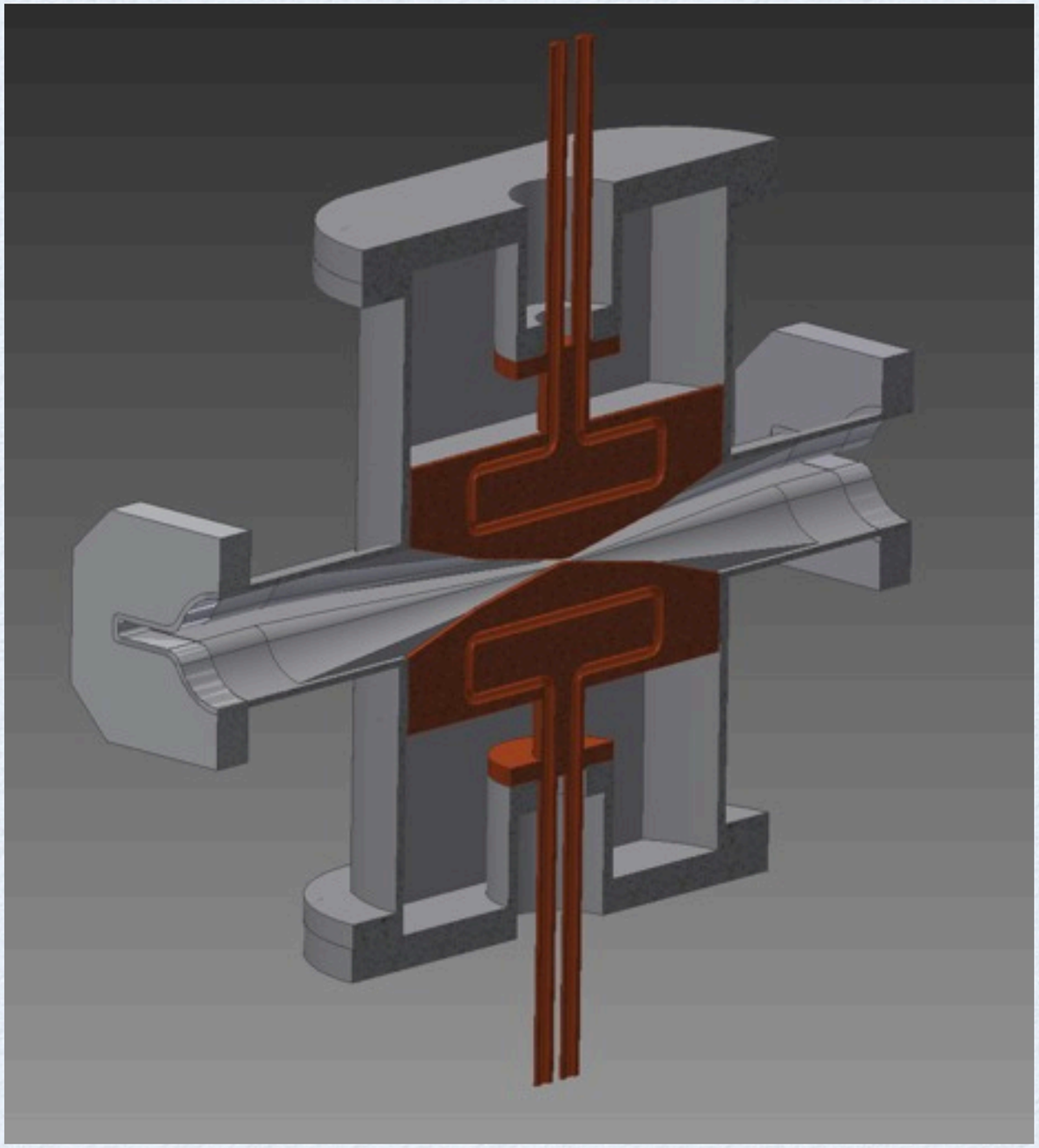
- The chamber and the heads are made from copper.
- The strokes of the movable heads are d=5~25 mm in horizontal and 2~12 mm in vertical.

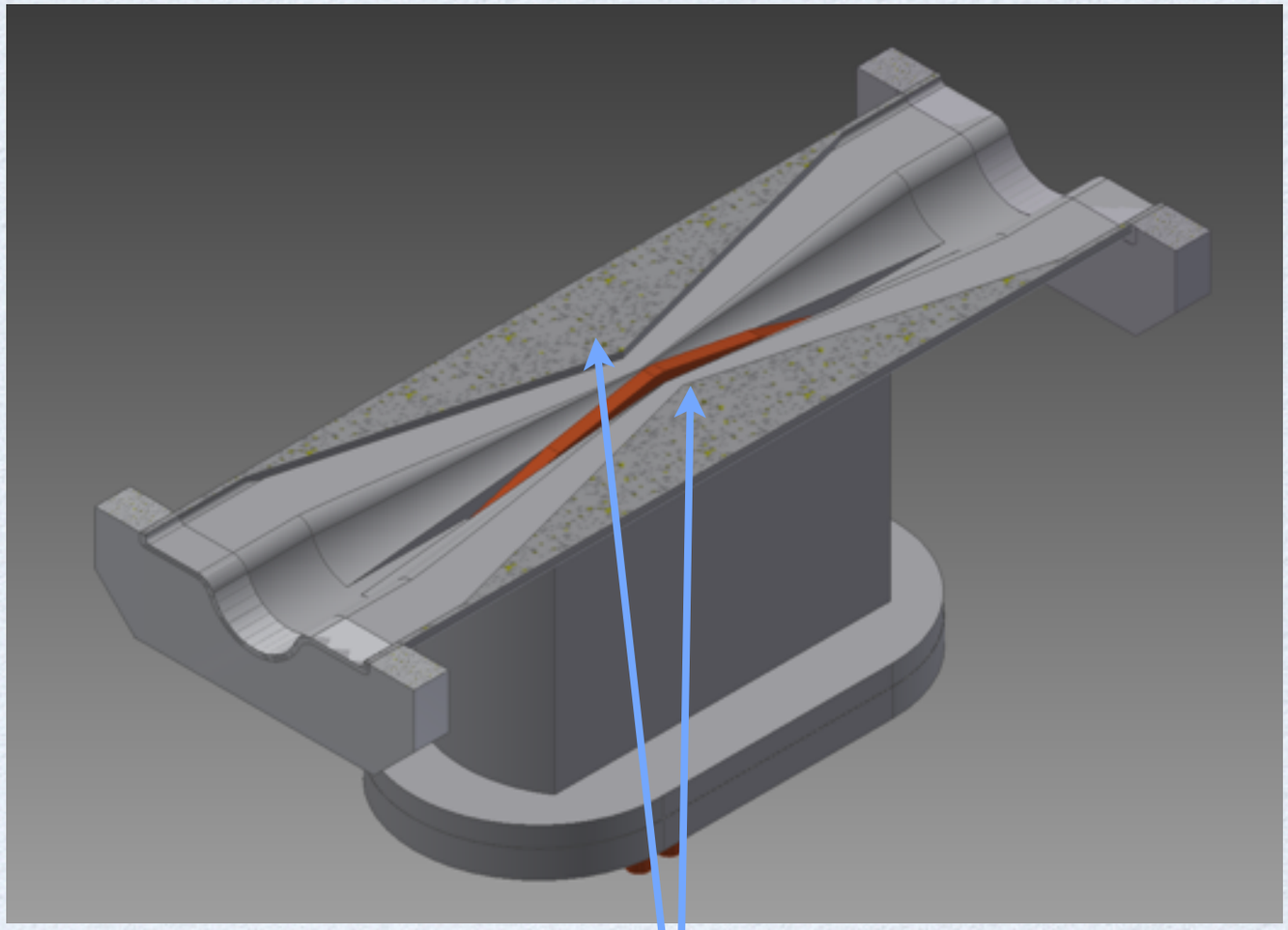
  (“d” refers to the distance between the central beam axis and the tip of the head.)
- The ramp have to be less than 30 degrees because of the heat load by SR.
- Tungsten is jointed at the tip of the head with Hot Isostatic Press (HIP, already succeed in the test).
- RF contacts are attached between the heads and chambers.



Vertical Collimator

- We're also designing the vertical collimator.

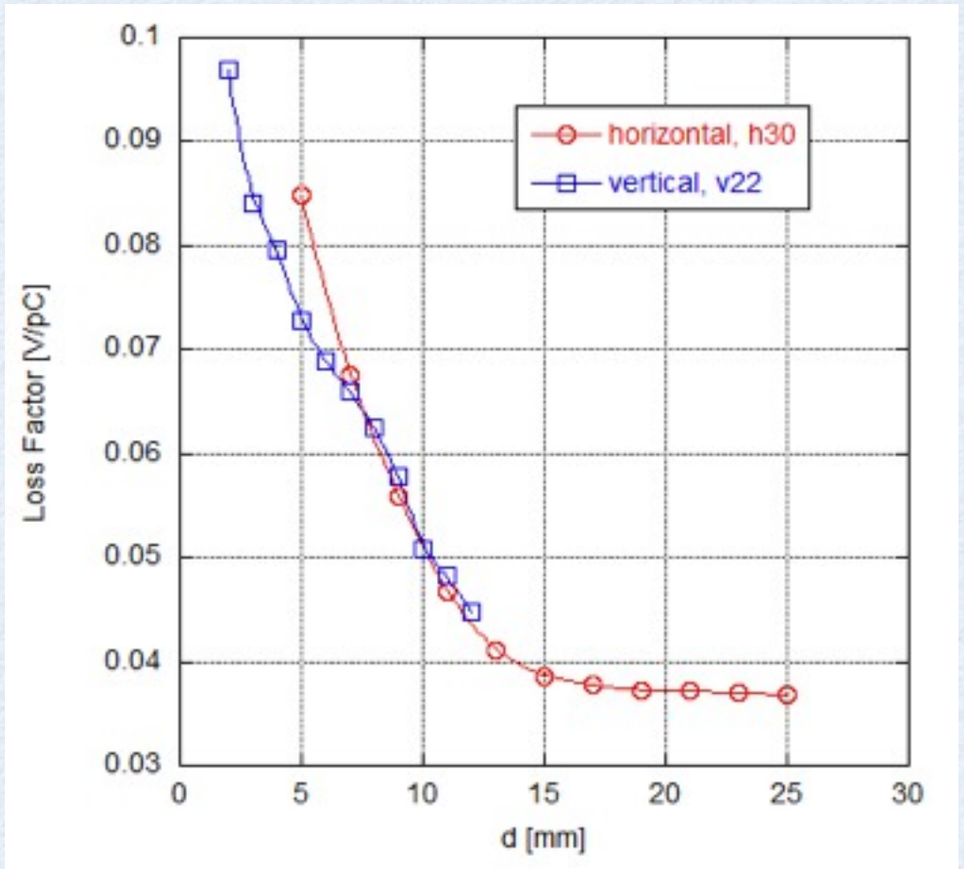


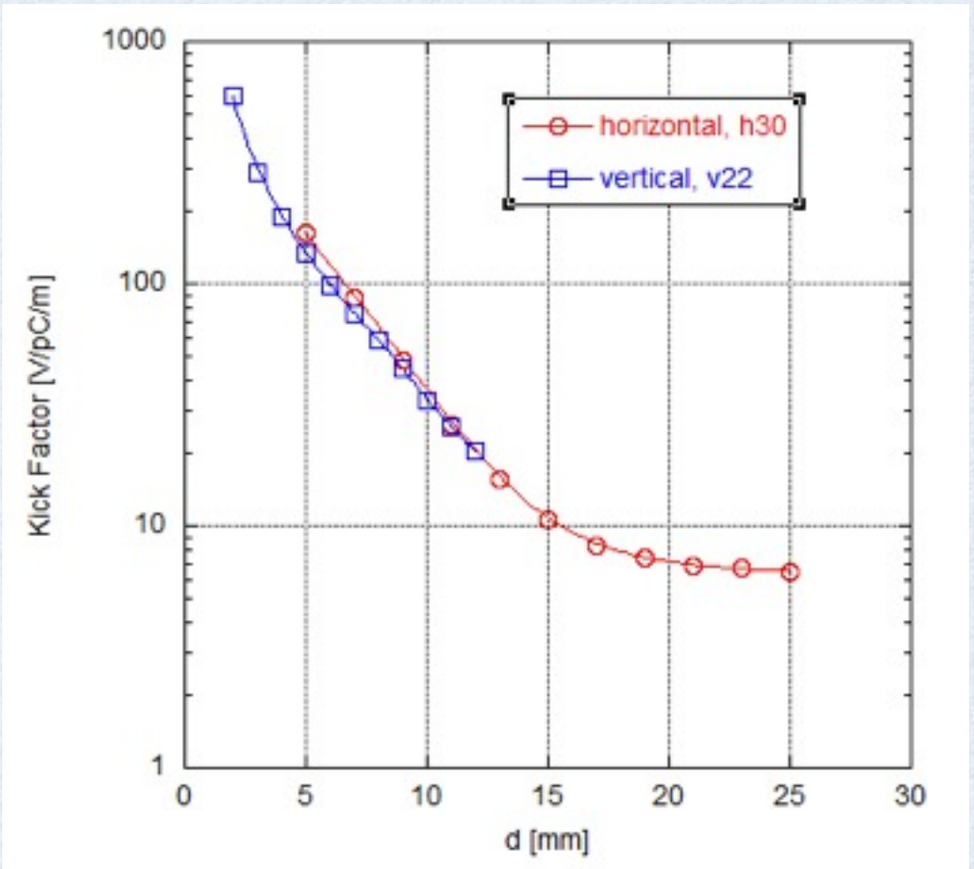


The inside of the antechambers would be tapered to avoid the trapped mode.

Loss & Kick Factor for Different “d”

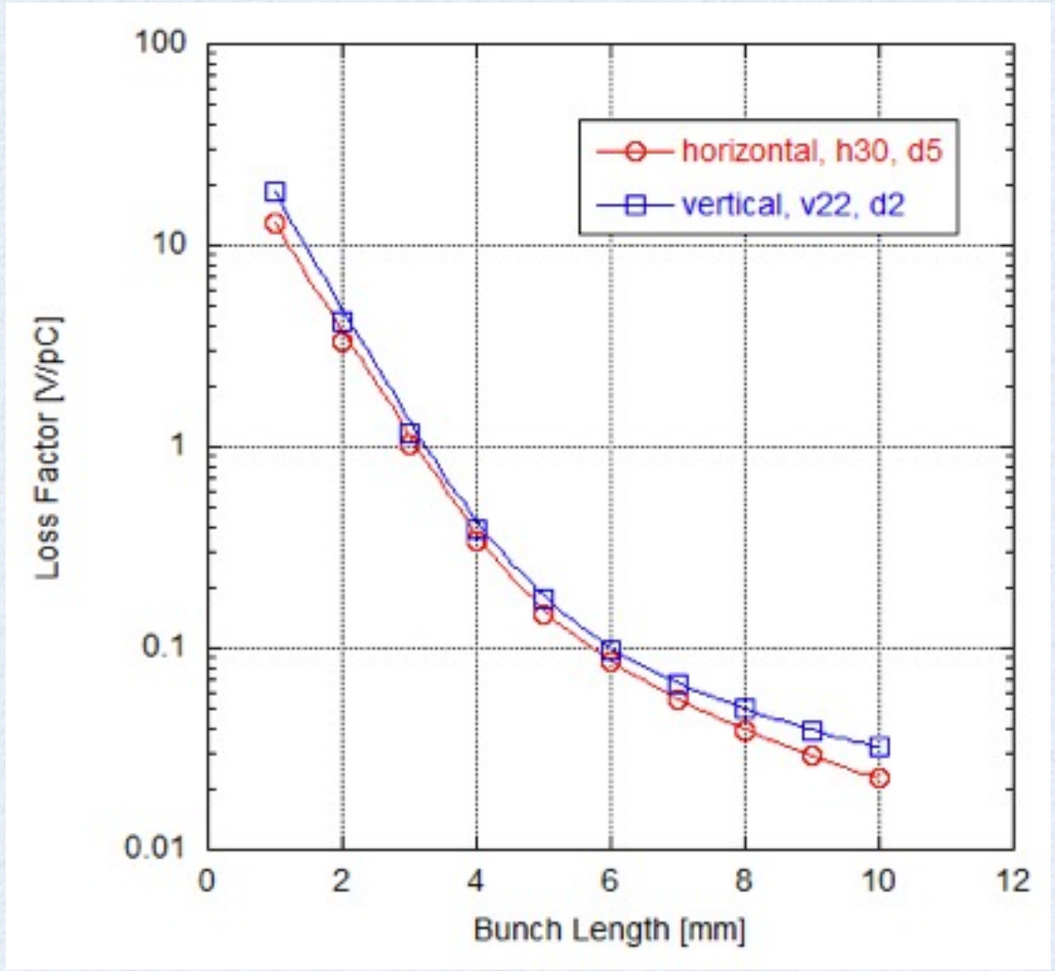
- Impedances are estimated with GdfidL (σ_z=6 mm).
- The radiation length of tungsten is about 3.5 mm, so the longitudinal length of the tip has been fixed to 10 mm (> 2RL).
- The loss factor is less than 0.1 V/pC per collimator.
- The loss factor between d=2 in vertical and d=5 in horizontal is about same.

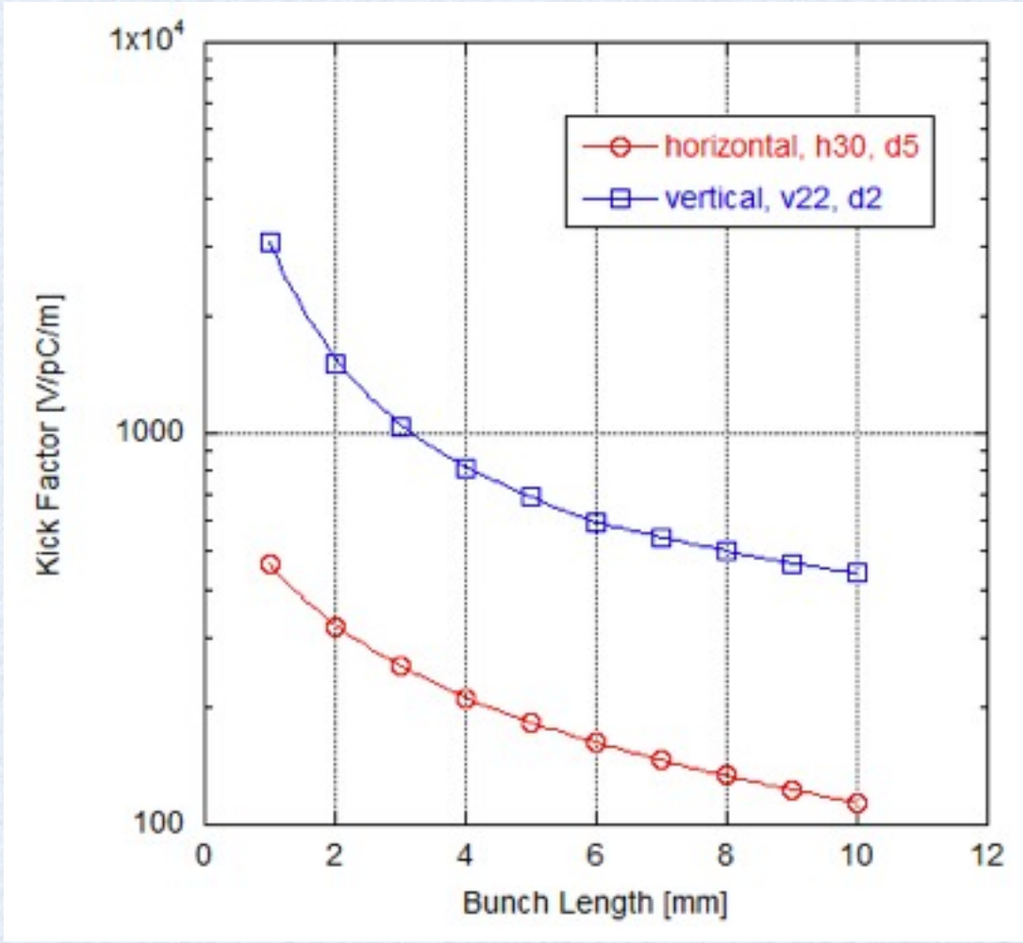




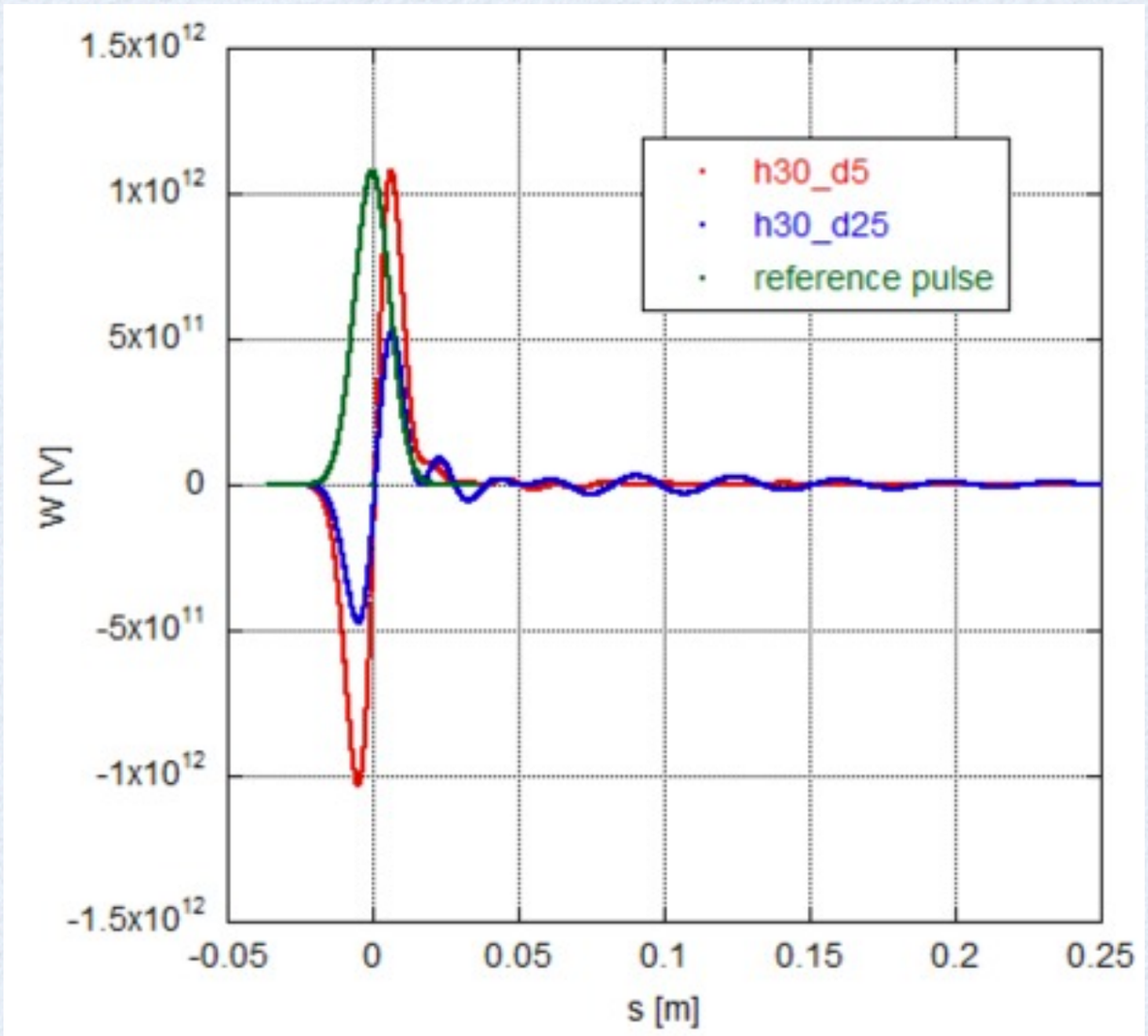
Loss & Kick Factor for Different Bunch Length

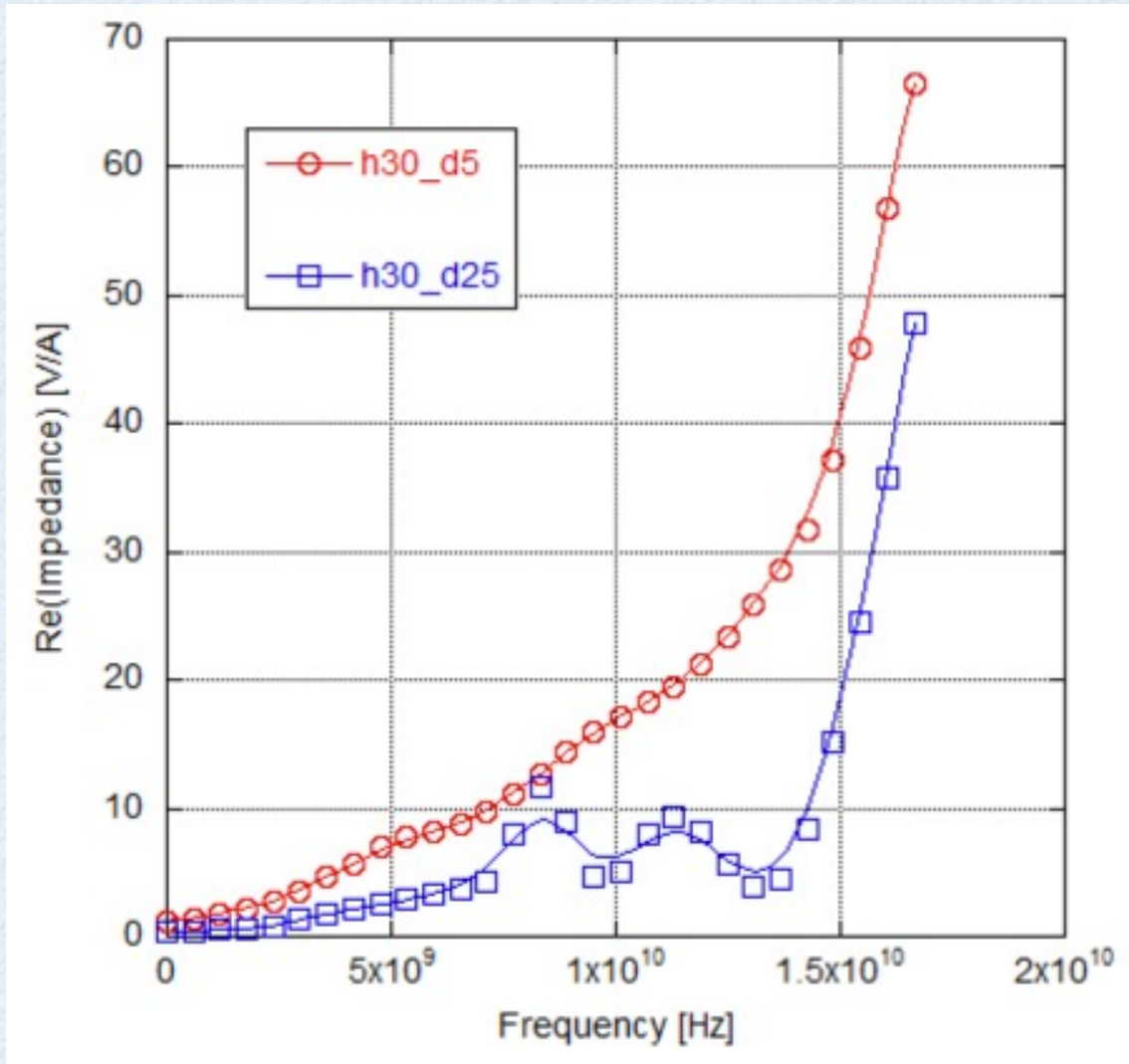
- Bunch Length: 6 mm(LER), 5 mm(HER)
- The factors are largely dependent on the bunch length.



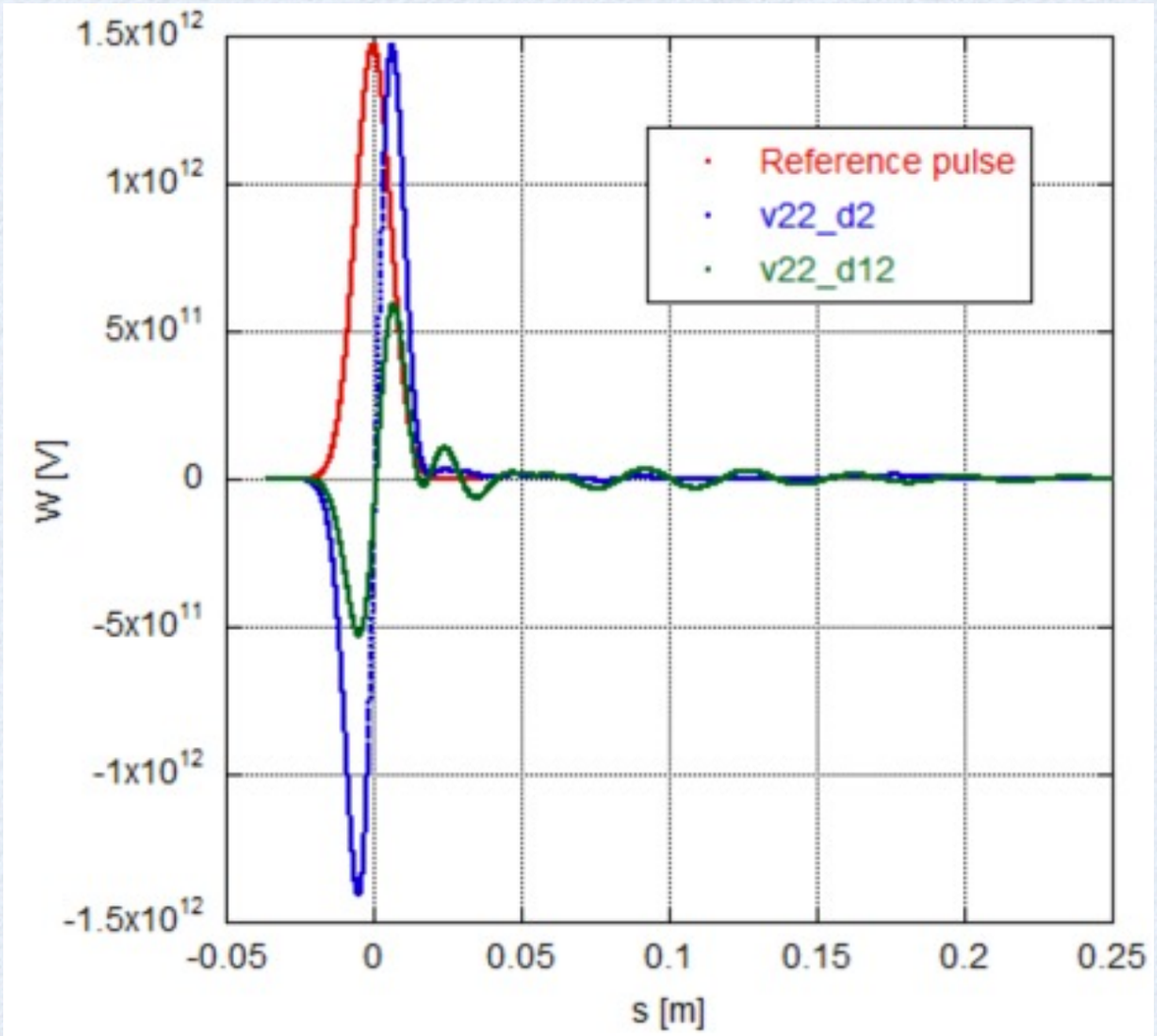


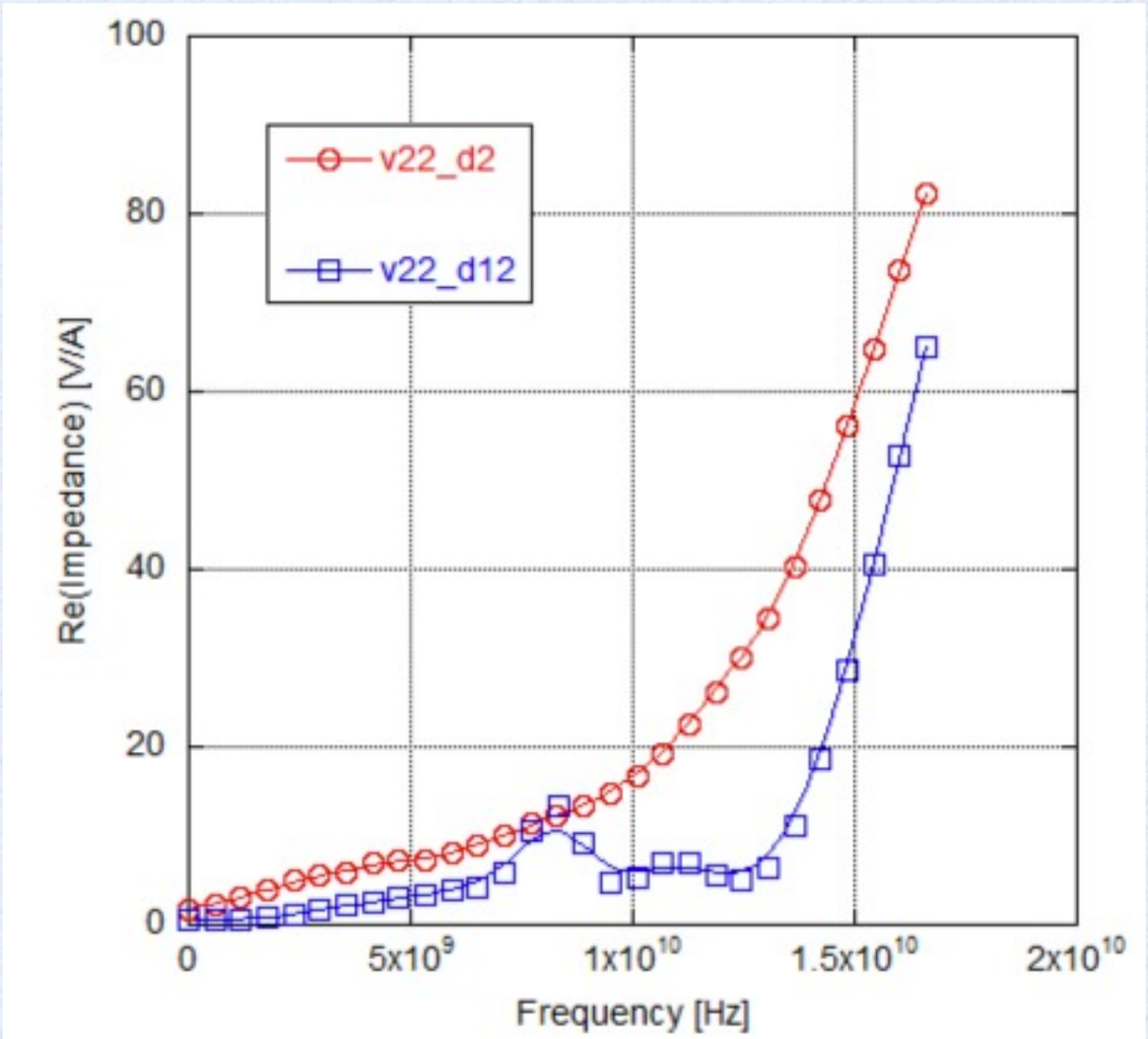
Impedance (Horizontal)





Impedance (Vertical)





Transverse Mode Coupling

- We estimated the threshold of the TMC using actual β value at each collimator (σ_z = 6 mm).
- When the collimator's apertures are all closed to the minimum (H: 5 mm, V: 2 mm), the bunch current would exceed the threshold.
- However, there would be no problem when we operate them within the designed aperture values.

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

		TMC Threshold (mA/bunch)		Bunch Current
		All Closed	Realistic Apertures	(mA/bunch)
LER	Horizontal	1.41	13.15	1.44
	Vertical	0.96	5.10	

Bunch Lengthening

thanks to D. Zhou

- The longitudinal wake-fields due to collimators are mostly inductive.
- We roughly estimated the inductance and the bunch lengthening using Zotter's equation.

$$\left(\frac{\sigma_z}{\sigma_{z0}}\right)^3 - \frac{\sigma_z}{\sigma_{z0}} - \frac{\alpha I_b Im(Z_\parallel/n)_{eff}}{\sqrt{2\pi}(E/e)\nu_{s0}^2}\left(\frac{R}{\sigma_{z0}}\right)^3 = 0$$

- The total inductance of the collimators in LER is about 16.3 nH.
  - 10.9 [nH] in horizontal + 5.4 [nH] in vertical
- σ_{z0} = 6 mm, σ_z = 6.96 mm; σ_{z0} = 5 mm, σ_z = 6.23 mm
- We may need to consider the mitigation method for suppressing the impedances.
- Demin Zhou has just started estimating the lengthening using his beam tracking code to look into the detail.

Future Plans

- A first prototype of the SuperKEKB type horizontal collimator is in the process of production, and it's scheduled for completion in March.
- We're going to test the motion of the movable heads, the mechanical property of the RF contacts, the control system and so on for the prototype.
- At the beginning of the commissioning, we have no plan to install HOM absorbers because the loss factor of the collimator is small.
- However, we continue to design the HOM absorbers.
- We're simulating and designing the vertical collimator.