

Operation Experience of HOM absorbers at KEKB

11-14 Oct., 2010

Takaaki Furuya, KEK

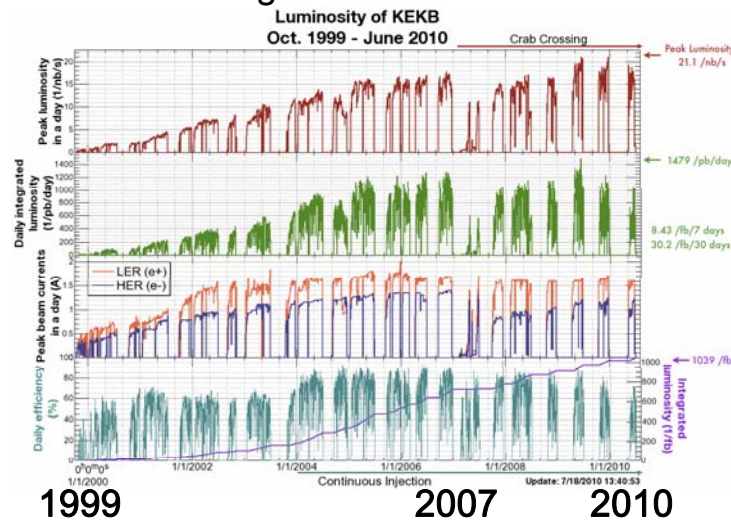
HOM absorbers of KEKB: for ampere-class beam

- 1) SC accelerating cavity (KEKB-SC): beam line damper
- 2) SC CRAB cavity: beam line damper
- 3) NC ARES cavity: beam line & wave guide
- 4) beam line tapers & movable masks: beam line

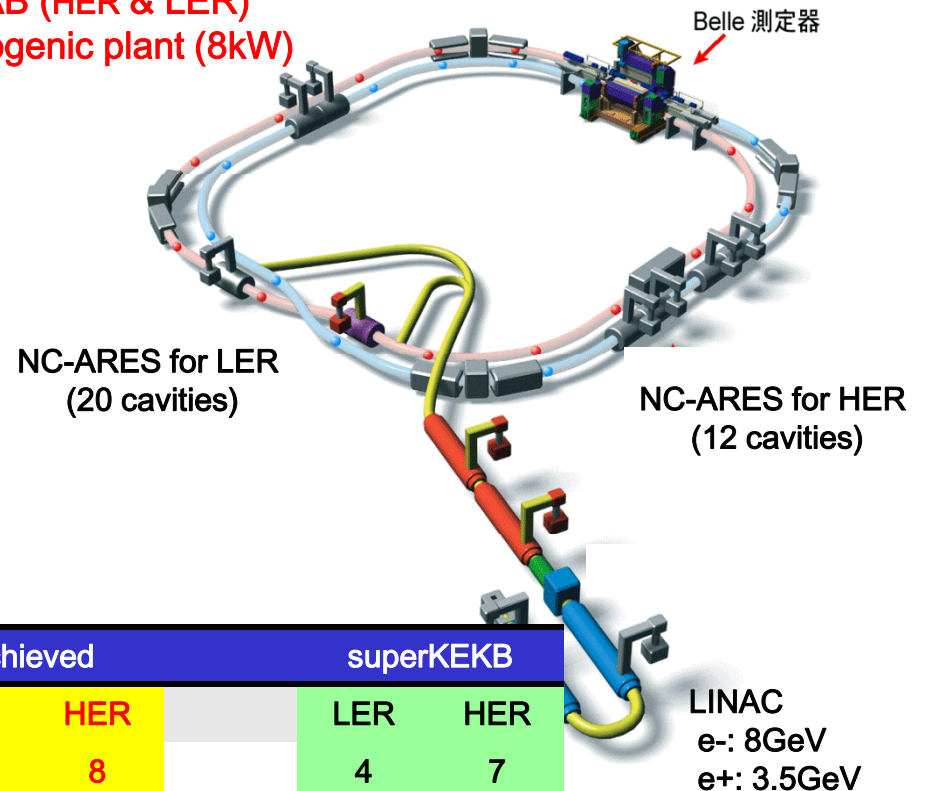
Performance Growth of KEKB

KEKB now?

- LER(e+/3.5GeV), HER(e-/8GeV)
- Performance growth



SC-RF (8 cavities)
 CRAB (HER & LER)
 Cryogenic plant (8kW)

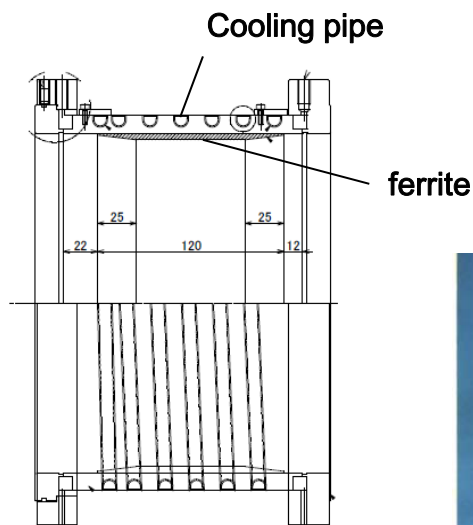
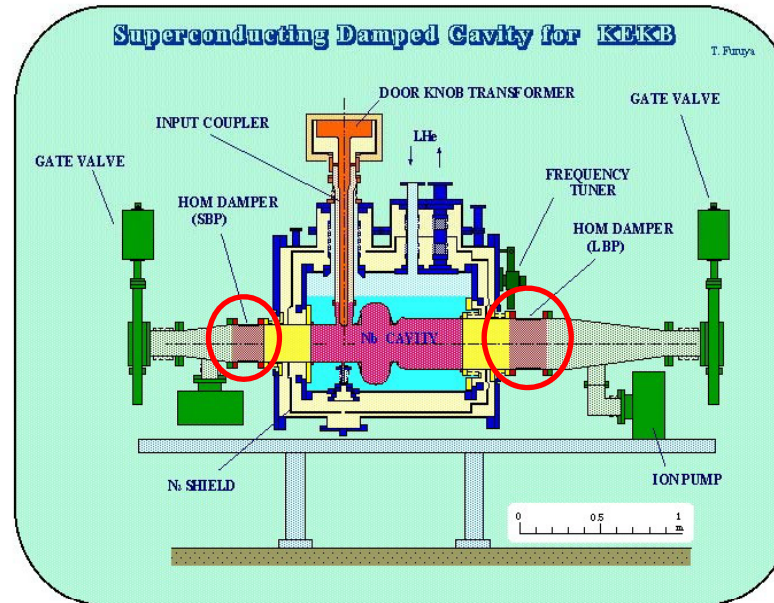


	design		achieved		2010-2013	superKEKB	
	LER	HER	LER	HER		LER	HER
Beam energy (GeV)	3.5	8	3.5	8		4	7
Beam intensity (A)	2.6	1.1	2	1.4	➔	3.6	2.62
Peak luminosity (cm ⁻² s ⁻¹)	1E+34		2.1E+34			80E+34	
Bunch charge (nC)	5	2	12	10		14	10
Bunch length (mm)	4	4	6	6		6	5

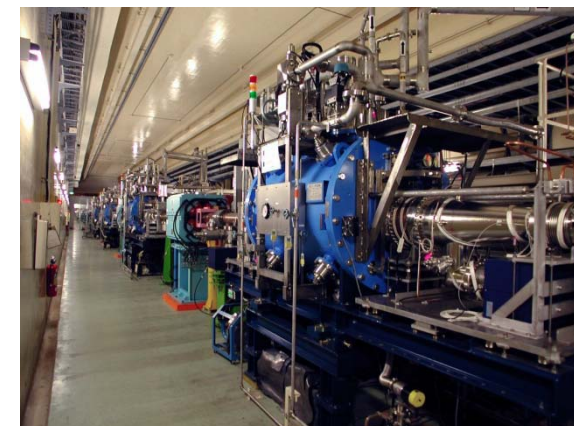
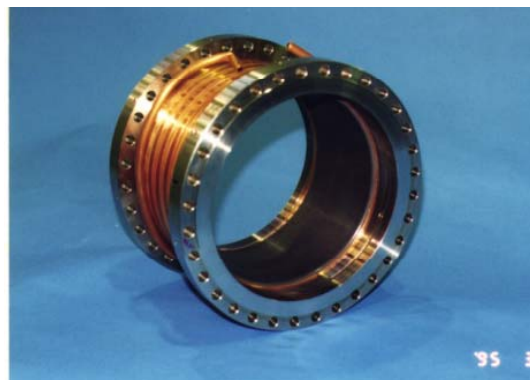
SC Accelerating Cavity

Module Structure

- 509MHz single cell cavity
- Cylindrical BP
- A pair of IB004 ferrite dampers (220φ & 300φ, 4mm in thick)
- HIPped cylindrical absorbers
- Long tapers to reduce k
- Module length: 3701 mm



Hot Isostatic Pressing
 (900C, 150 MPa)

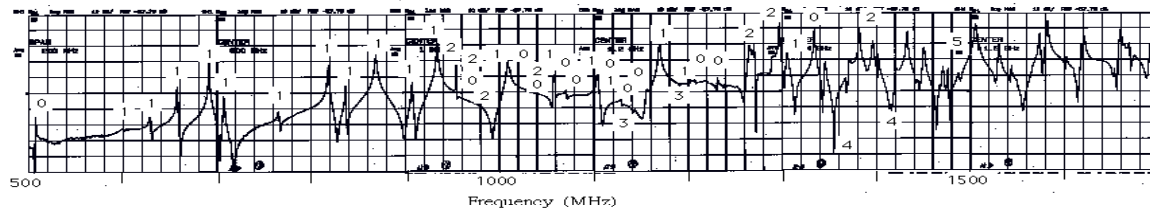


Damping parameters

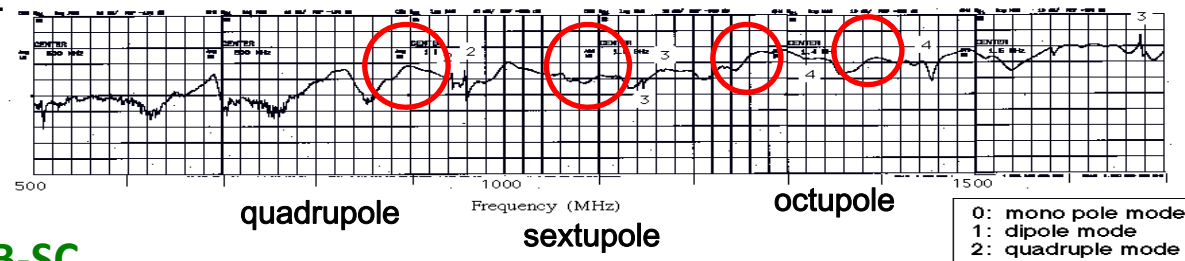
Damping parameters

- CBI: coupled bunch instability
- Damping time
 - longitudinal: 20 ms
 - transverse: 40 ms
- Lowest multi-poles still remain.

Al model cavity without Ferrite



Nb cavity with Ferrite (at Horiz. Test)



Figures achieved by KEKB-SC

(KEKB achieved)

- Q_{in} of $5E+04$
- P_{beam} of 350 kW/cavity
- HOM of 14-16 kW/cavity

(supreKEKB)

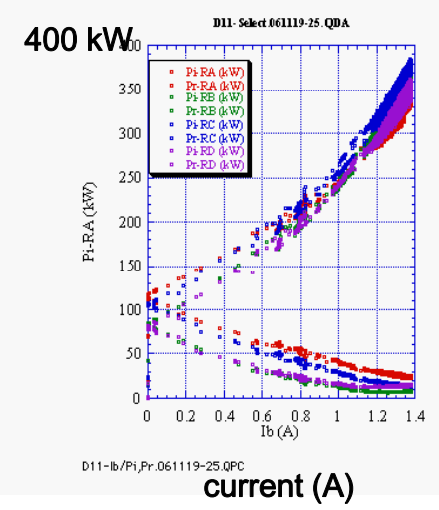
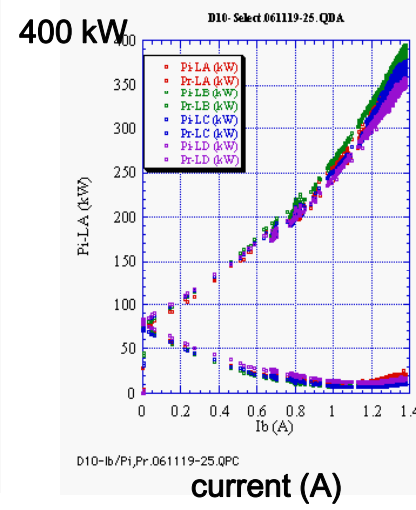
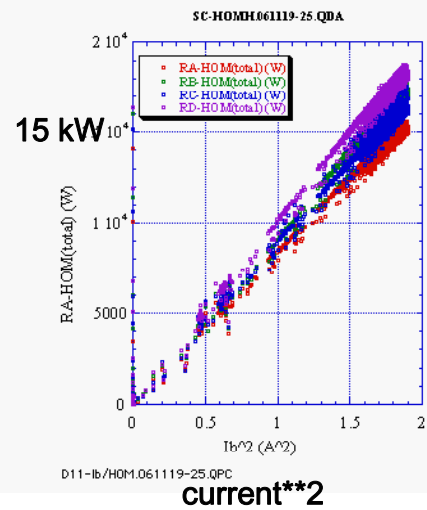
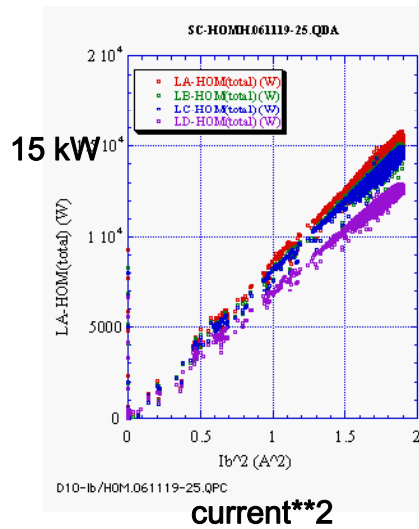
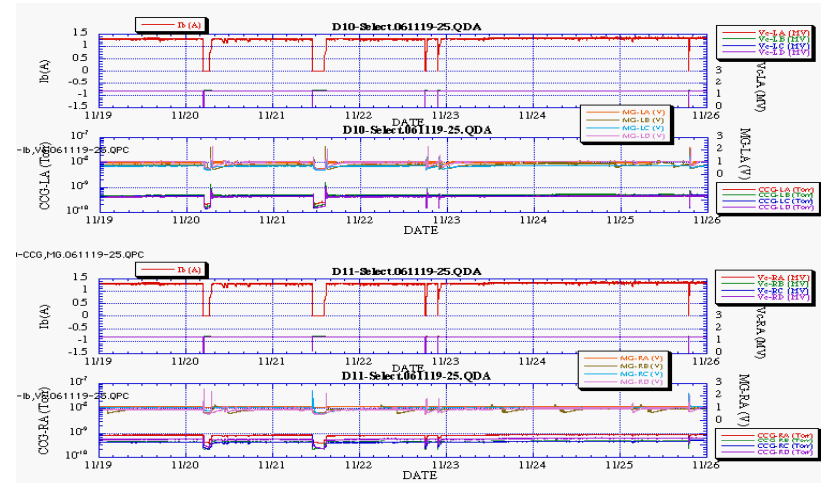
- HOM of 41 kW/cavity
(SBP: 16kW, LBP:24 kW)
- Reduce 4mm \rightarrow 3mm
(power tested to 18+25 kW)
- Ferrite surface reaches 160C?
(Curie temp is 240C)

	design	achieved	superKEKB
No. of cavities	8	8	8
Max. beam current (A)	1.1	1.40 (127%)	2.62
No. of bunches	5000	1389	2503
bunch charge (nC)	2.2	10.1	10
Bunch length (mm)	4	6 - 7	5
RF voltage (MV/cavity)	1.5	1.2 - 2	1.3
unloaded Q at operation	$1E+09$	$0.3 - 1 E+09$	$1E+09$
beam loading (kW/cav)	>250	350 - 400	400
HOM loading (kW/cav)	5	14 - 16	41

HOM power

HOM Power & Input power

- Top-up operation
- HOM power reached 12-16 kW
- RF delivery to the beam is 350 kW/cavity



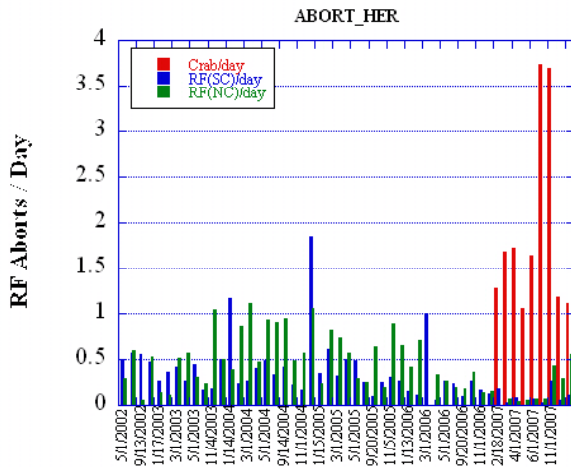
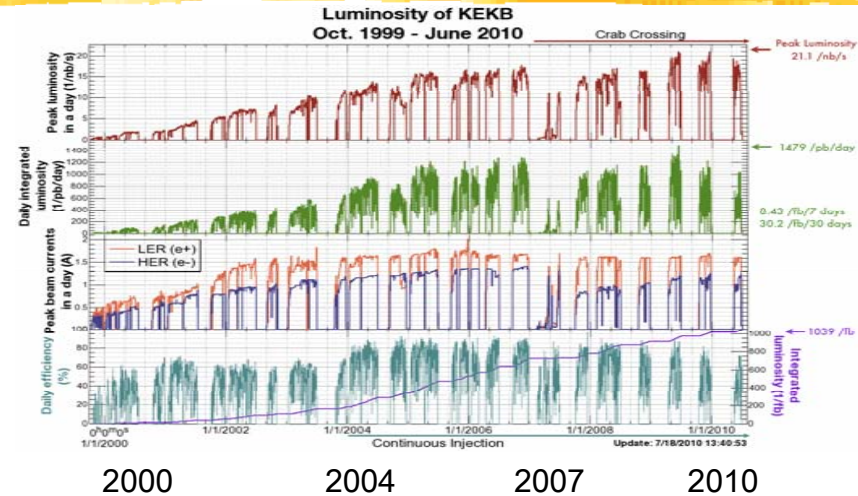
Cavity performance & trips

RF trips and degradation

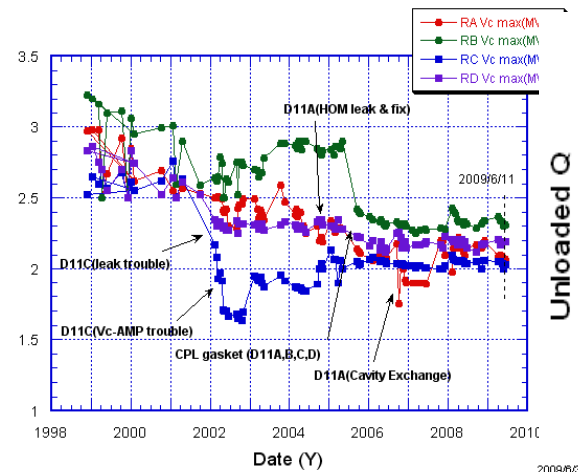
- Trip rate of 0.5/day for 8 cavities
- Improved to 0.1/day at a small current of 1.2A

- Vc max degrade gradually by quench
- Q0 also reduced by electron emission
- No baking to avoid He-leakage at In-sealing

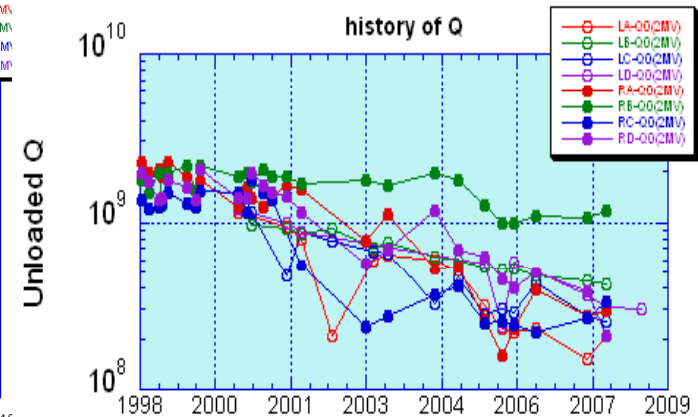
- Outgas of ferrite causes discharging?
- Ferrite powder degrades the performance?



Trip rate of HER-RF
(2002-2008)



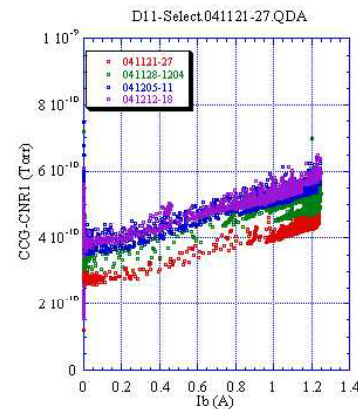
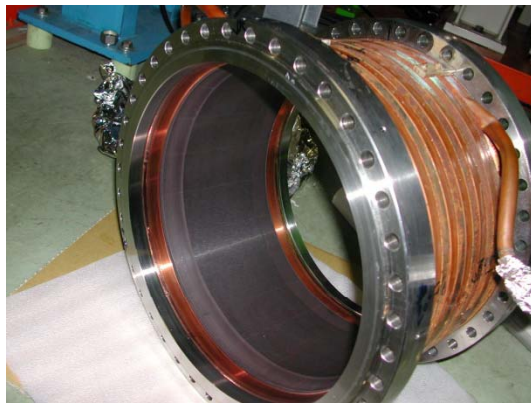
Vc max (MV)
(1999-2010)



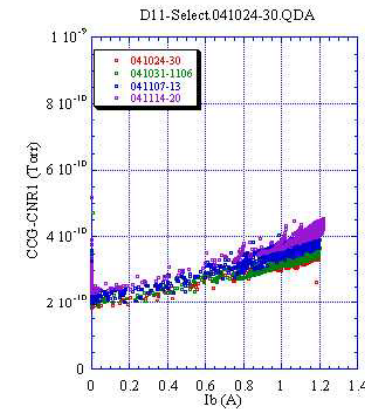
Q at 2MV
(1998-2008)

Vacuum leak at HOM damper flange (Dec,6, 2004)

- Suddenly coupler arc I/L worked, and gradually the interval of trips became short. (every two hours)
- Conditioning of the coupler gave no change of situation.
- vacuum leak on the welding seam was found by a leak check after warming up.
- record of vacuum pressure showed the leakage had happened one week before.
- The damper was replaced to a new one.



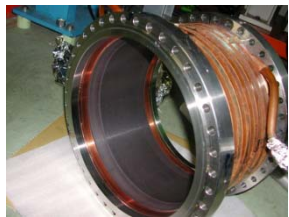
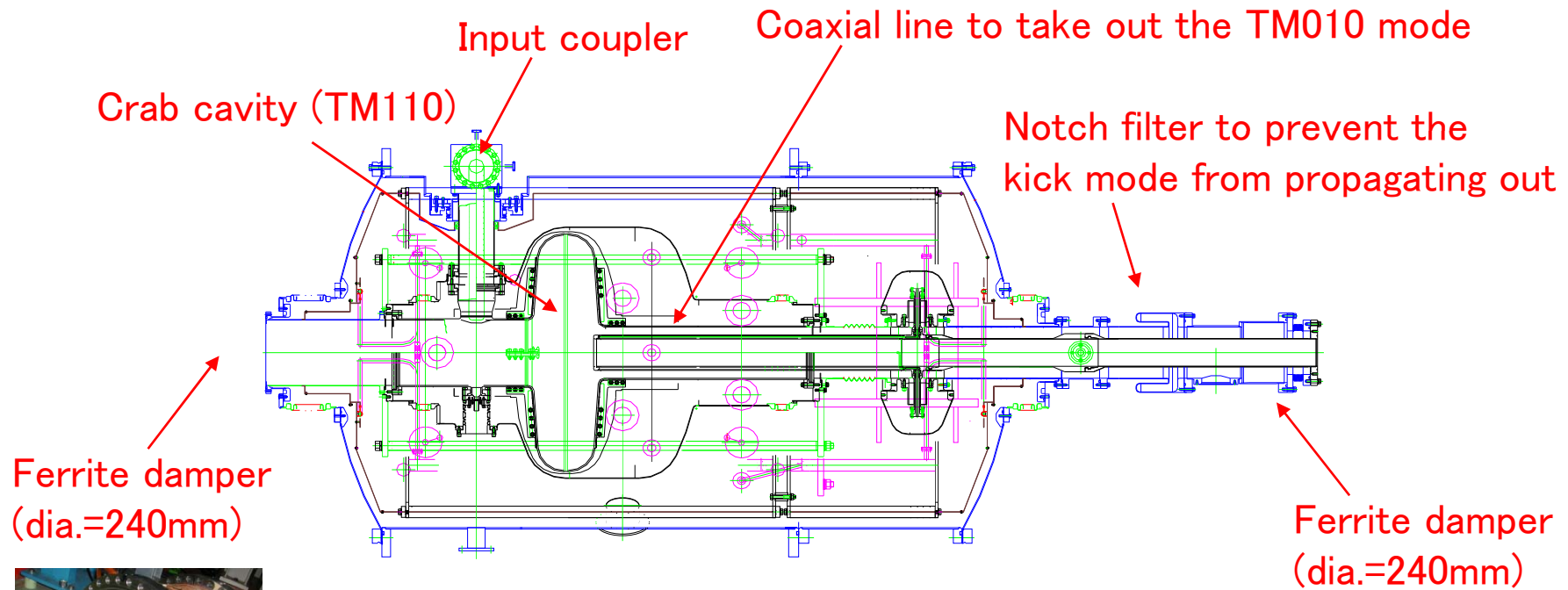
プラットフォーム 30
Vacuum
 (Nov/21-Dec/18,2004)



プラットフォーム 31
Vacuum
 (Oct/24-Nov/20,2004)

CRAB cavity

Damping scheme of the Crab cavity (509MHz)



- Horizontal kick to compensate a finite crossing angle
- LER-CRAB has additional SiC dampers at taper sections to connect the beam line.



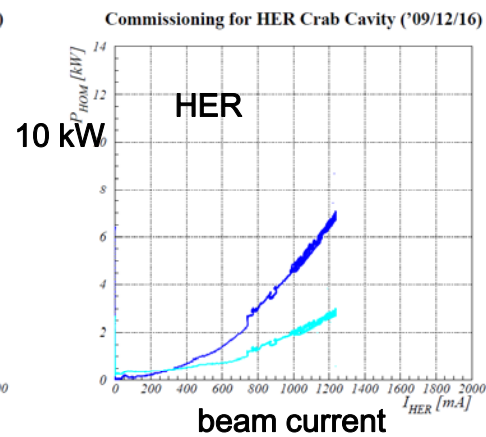
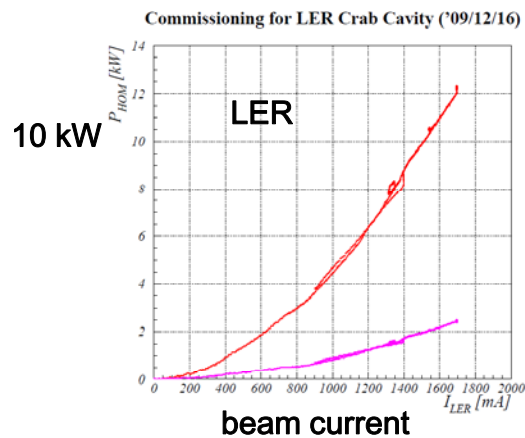
CRAB cavity

HOM'10 at Cornell U.
2010/Oct/11-14
T. Furuya, KEK

Achieved performances

By Morita, Yamamoto

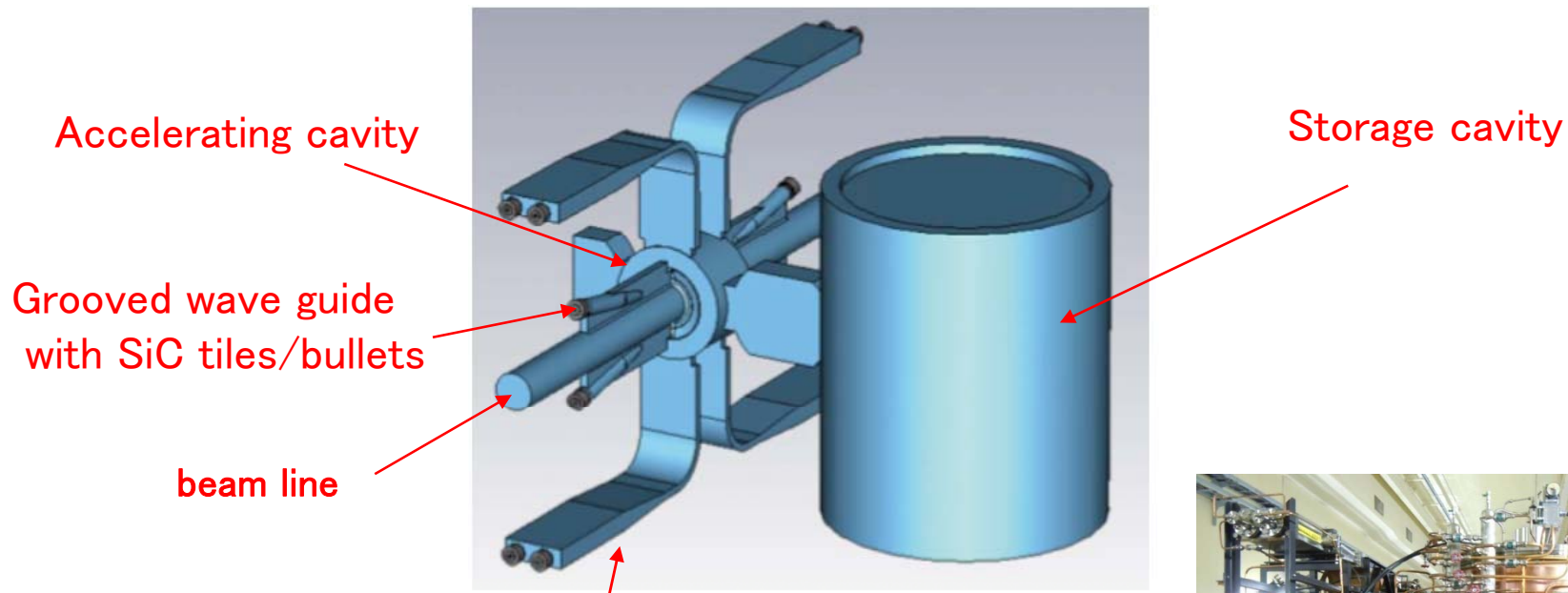
contents	unit	LER	HER
Beam current (Crab ON)	mA	1700	1250
Crab voltage (operation)	MV	0.8~1.0	1.3~1.6
Crab voltage (Max.)		1.1~1.5	1.7~1.8
Max. HOM Power	kW	2.5(coax)+12.4(LBP) 13.0(SiC1) +12.2(SiC2)	3.0(coax)+6.9(LBP)
# of Piezo breakdown	count	5	4
operation temperature	K	3.6~4.2	3.6~4.2



ARES cavity (normal conducting)

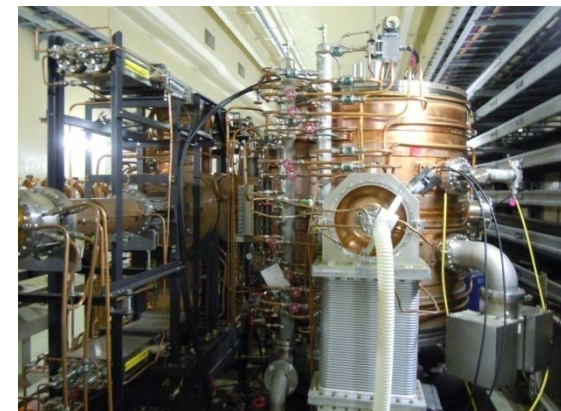
Structure of ARES cavity

- Accelerator Resonant coupled with Energy Storage



T. Abe and Y. Takeuchi

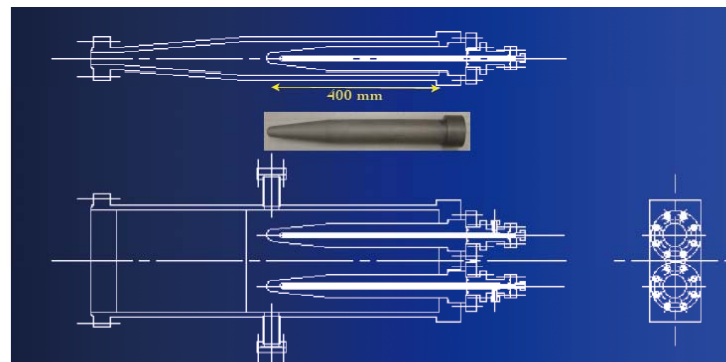
Wave guide damper with SiC bullets



Dampers of ARES cavity

Wave guide damper

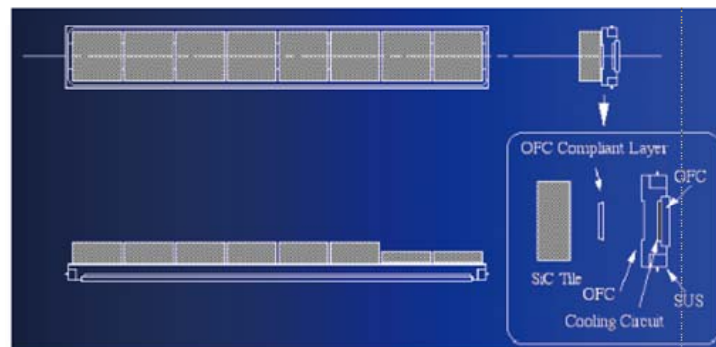
- Wave guide damper is terminated with two bullet-shaped SiC absorbers.
- Power capacity is **10 kW/bullet x 2 x 4**.



Y. Takeuchi

Grooved wave guide damper

- Each groove has eight SiC tiles brazed on a water cooled Cu plate.
- Power capacity is **1 kW/groove x 4**.



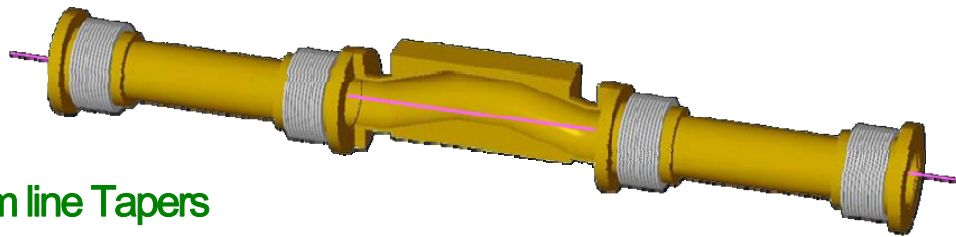
HEXOLOY:

	KEKB LER	superKEKB LER
Current (A)	1.6	3.6
No of bunches	1292	2503
σ_z (mm)	7	6
k (V/pC)	0.40	0.44
HOM/ARES (kW)	5.4	17
HOM/WG (kW)	1.05	3.3
HOM/groove (kW)	0.3	0.93

CERASIC B:

Movable Masks

- Mask chamber and bellows sections on both sides are the source of HOM impedance.
- Grooved wave guide damper with a pair of SiC bullet (HEXOLOY) is located on the upstream side.
- Absorbed power is **5.4kW** at 1.6 A.



Beam line Tapers

- Cylindrical absorbers made of SiC (CERASIC B)
- Absorbed power is **15 kW** at 1.6 A.

