20120221
MAC2012
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Improvement of superconducting cavities

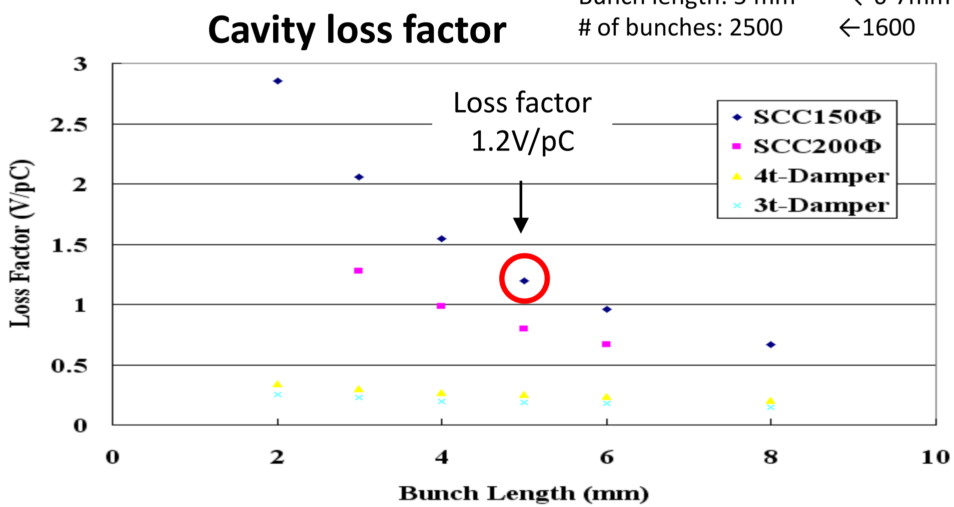
Handling of large HOM powers

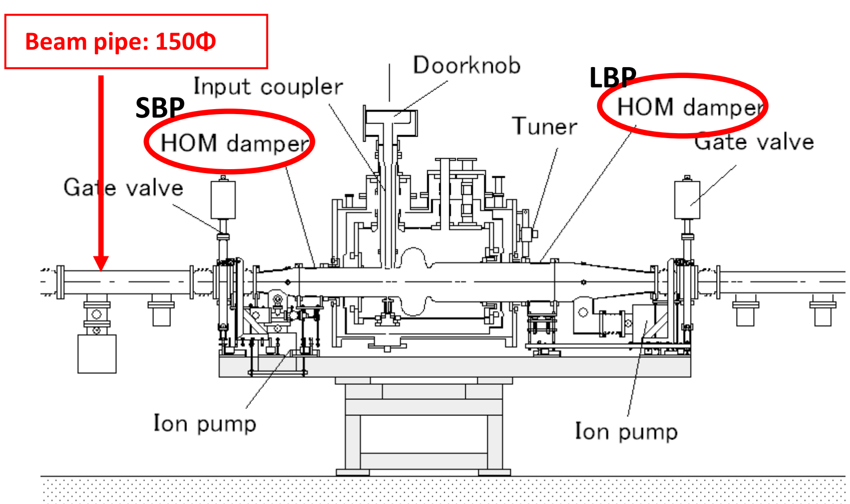
Recovery of degraded cavities

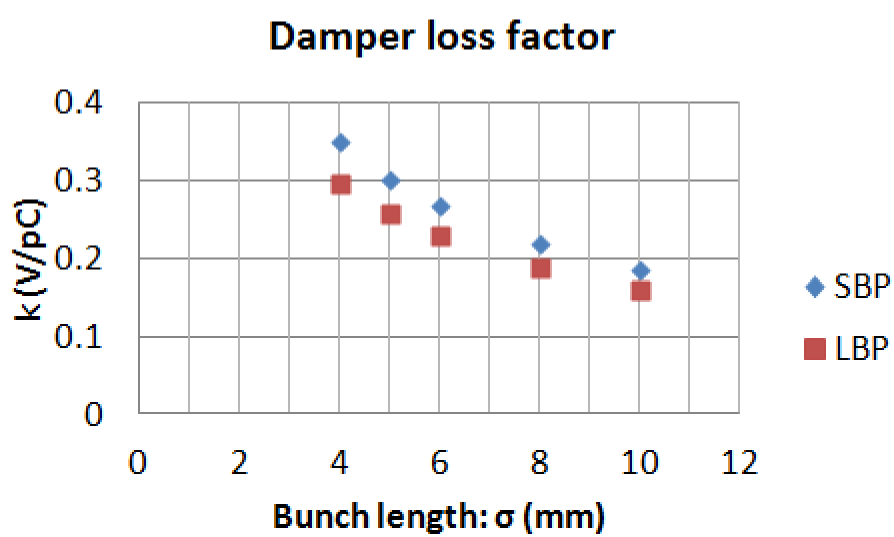
Machine parameters and HOM power

- Machine parameter of SuperKEKB/HER
  - Beam Current : 2.6A/2500 bunches
  - Bunch length : 5mm
- HOM power
  - Cavity loss factor : 1.2V/pC @σ=5mm
  - Expected HOM power : 31kW
  - LBP damper load : 26kW
    - Damper loss=0.26 V/pC
  - SBP damper load: 20kW
    - Damper loss=0.30 V/pC
  - Total heat load per cavity : 46kW

Parameters of HER
Maximum current: 2.6A ←1.35A
Bunch length: 5 mm ←6-7mm
# of bunches: 2500 ←1600





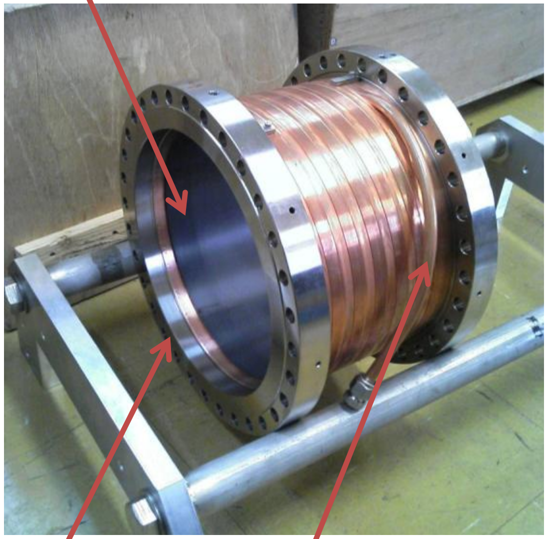


Issues related to present ferrite HOM damper system

- Ferrite material is sintered on a copper base pipe by hot isostatic press (HIP) method.
- Ferrite
  - Thickness: 4 mm
  - Ferrite surface temperature ：190℃ @2.6 A
  - Gas release from ferrite triggers high voltage breakdown
- Cooling water
  - Water temperature＜60℃
    - To prevent air bubbles
    - Deaeration system >60℃
- Chiller unit
  - Total heat load：46 kW per cavity
  - Cooling capacity（with a safety margin）：60kW
  - Cooling capacity of present chiller: 27 kW

Beam current	SBP load	LBP load
(A)	(kW)	(kW)
2	12	15
2.6	20	26

HIPped ferrite（Thickness：4mm）

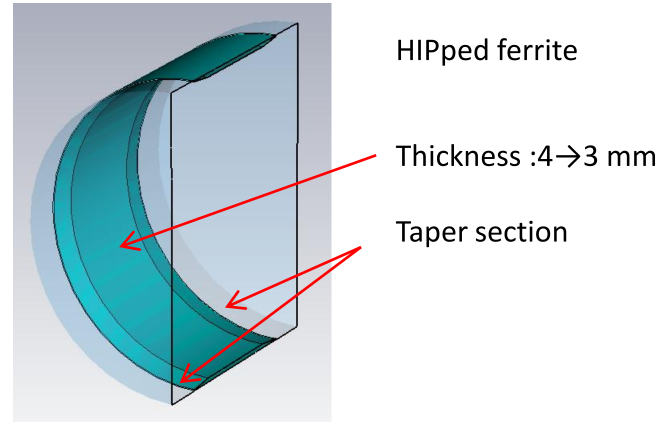


Cupper pipe (3/8”) for cooling channel

Flange: Stainless steel

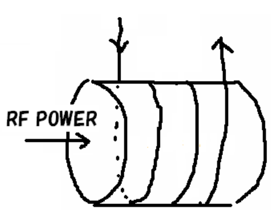
Development of new HOM dampers for SuperKEKB

- To suppress gas release from ferrite material
  - Suppress temperature rise of ferrite
  - Use 3 mm thick ferrite (KEKB damper: 4 mm)
    - For better thermal conduction
    - Damper loss factor is expected to be reduced
      - 1/3 of the total load is damper self loss

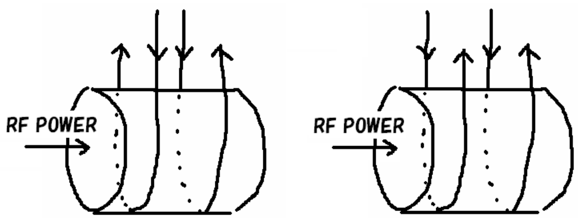


Prototype damper with 3 mm thick ferrite

- To suppress temperature rise of cooling water
  - Introduce double cooling structure



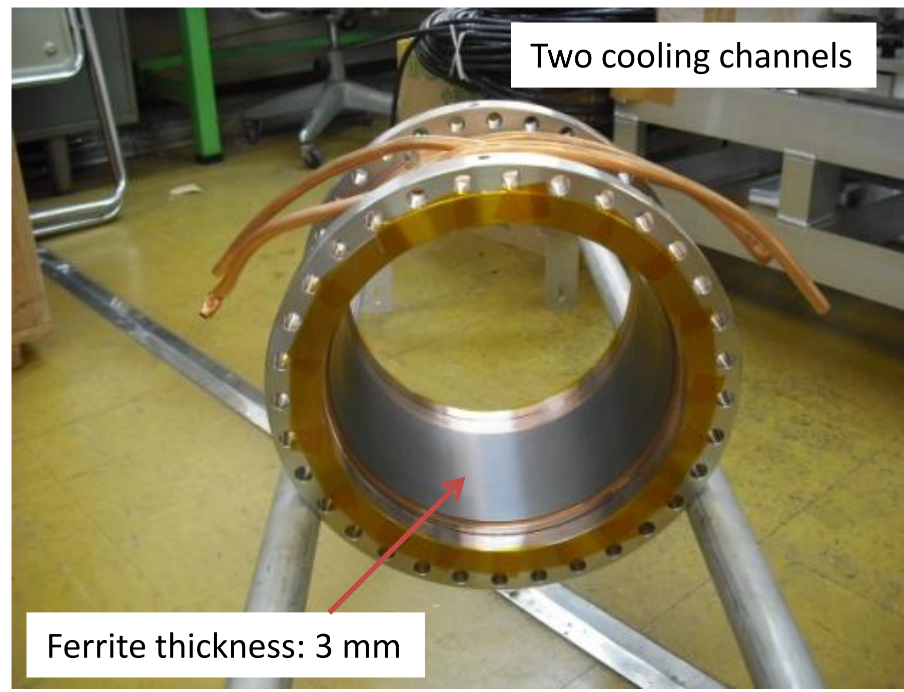
Single cooling structure



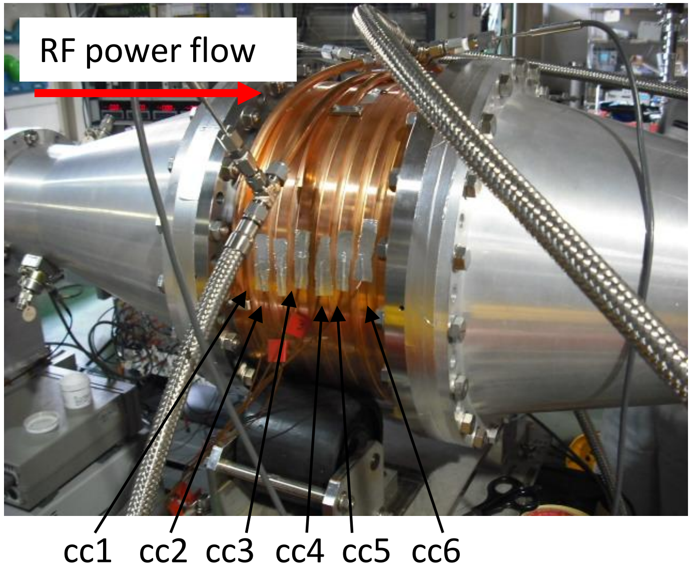
A-type cooling

B-type cooling

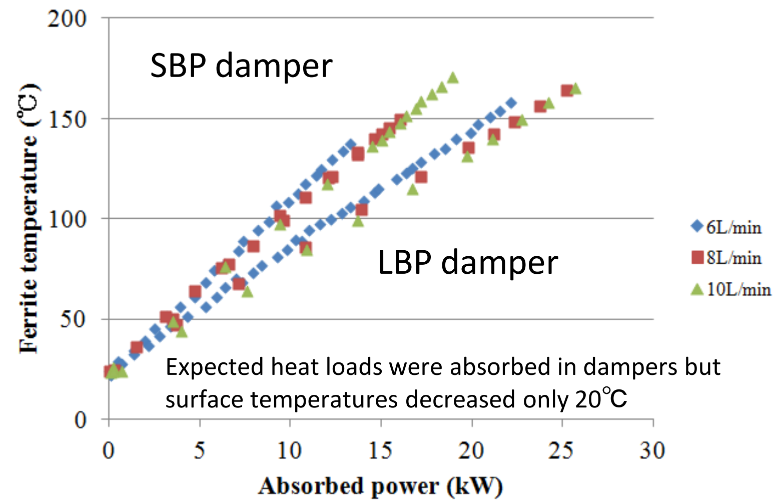
Double cooling structure



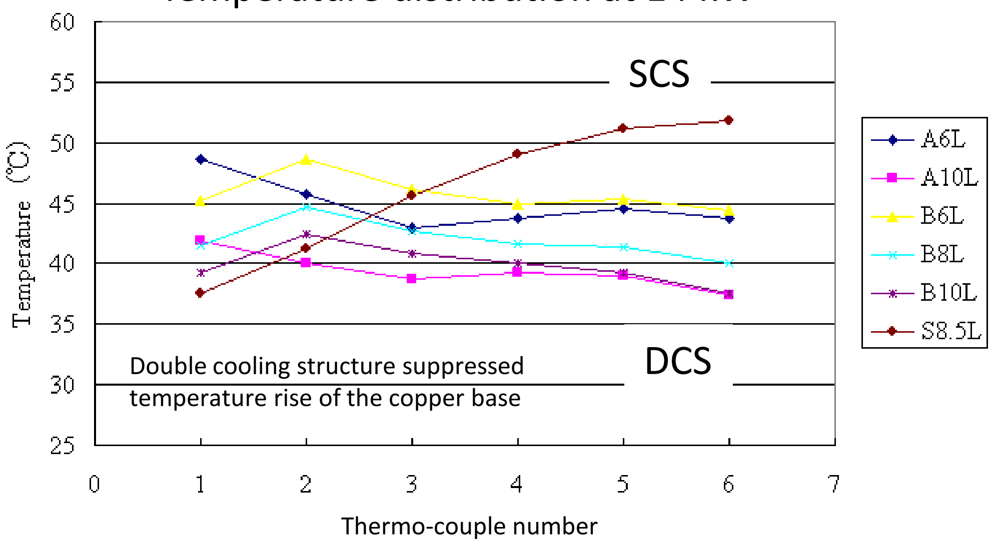
High power test results
3mm thick dampers with double cooling structure



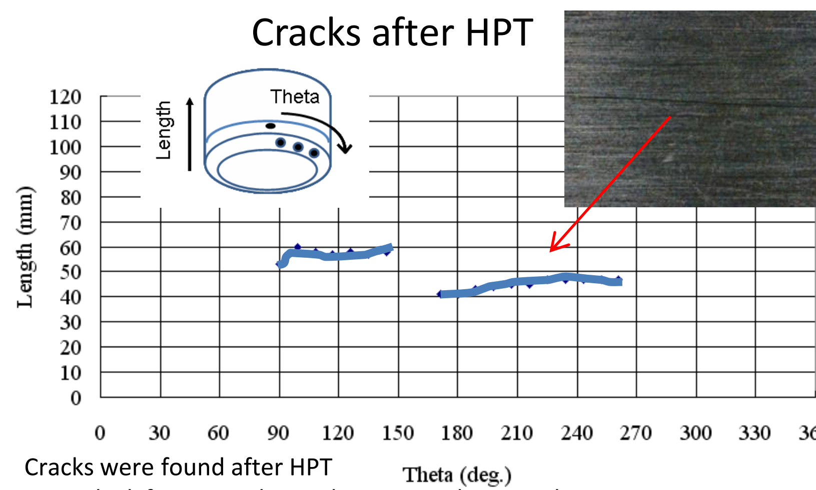
Absorbed power



Temperature distribution at 14 kW



Cracks after HPT

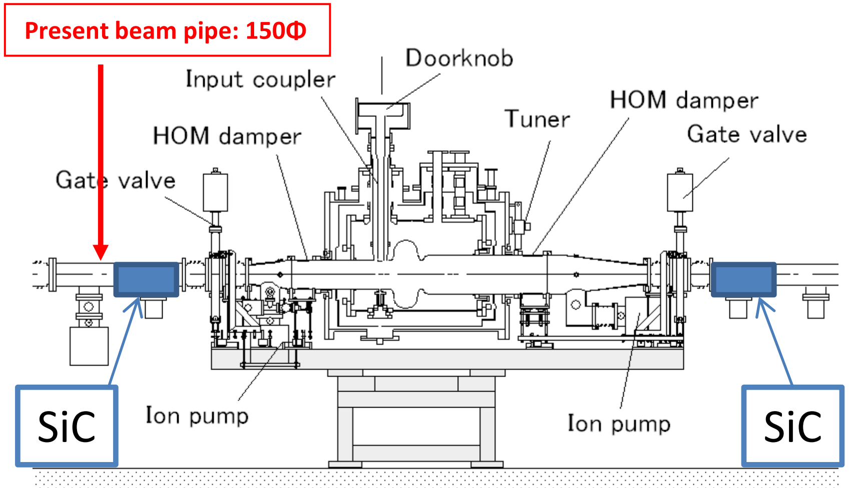


Cracks were found after HPT
3mm thick ferrite might not have enough strength

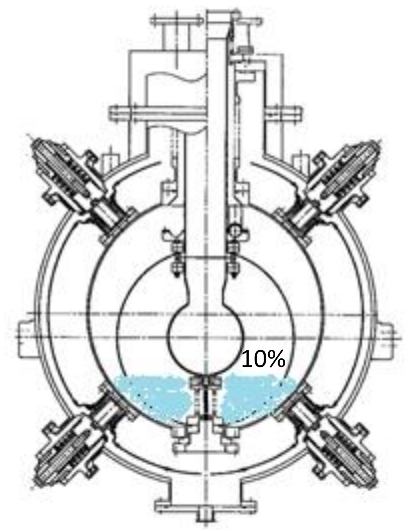
Other methods to handle large HOM power

- Enlarge beam pipe diameter
  - 150ϕ→200ϕ
  - Decrease loss factor
  - Decrease HOM power
- Additional dampers
  - Add SiC dampers on the beam pipe
  - To reduce ferrite damper load
  - Studies for SiC damper

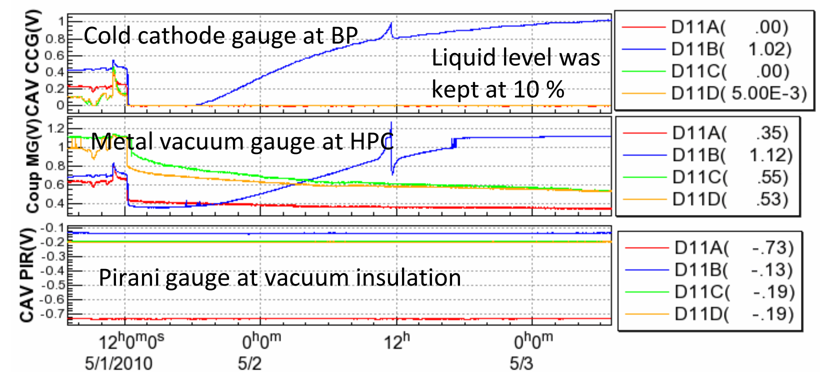
Beam pipe structure	Loss factor @σ=5mm (V/pC)	Modifications to be made
Present BP (150ϕ)	1.2	
200ϕ BP	0.8	GV dia. Bore dia. (Q-mag.)
200ϕ BP Taper (200ϕ→150ϕ)	0.95	GV dia.
200ϕ LBP only Taper (200ϕ→150ϕ)	1.05	LBP-GV dia.

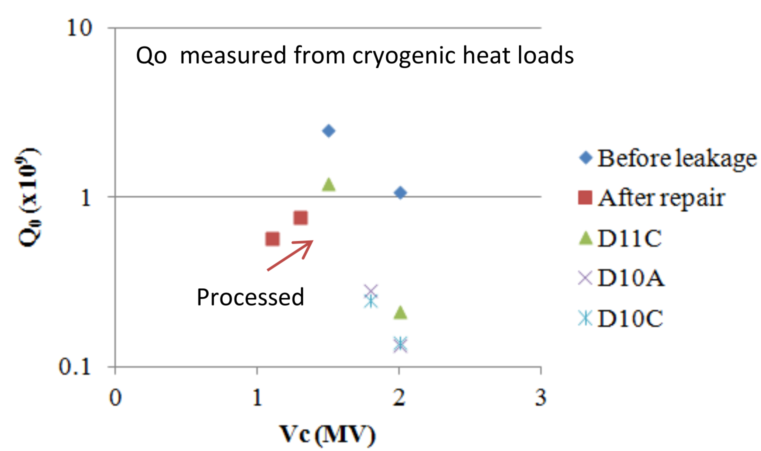


Recovery of degraded cavities
Vacuum leakage



- Vacuum leakage happened at cooldown in May 2010
  - Indium sealed flange was suspected as a cause
- The cavity was removed from KEKB ring
- The cryomodule opened
  - Bolts tightening flanges were loose (60kgfcm)
  - Thermal cycles might loosen those volts
  - Those bolts were retorqued (150kgfcm)
- Cooled and high power tested
  - No vacuum leakage
    - Loose bolts were cause of the leakage
  - Degraded with strong field emissions
    - Voltage reached 1.3 MV
    - Limited by the radiation safety rule
    - Cavity surface was probably contaminated with dust particles
- Q factors of other cavities
  - D10A, D10C, and D11C degraded with field emissions at high fields
  - Still acceptable for SuperKEKB operation
  - Recovery of degraded cavity is desirable for long time operation

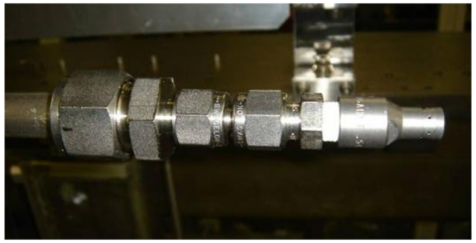




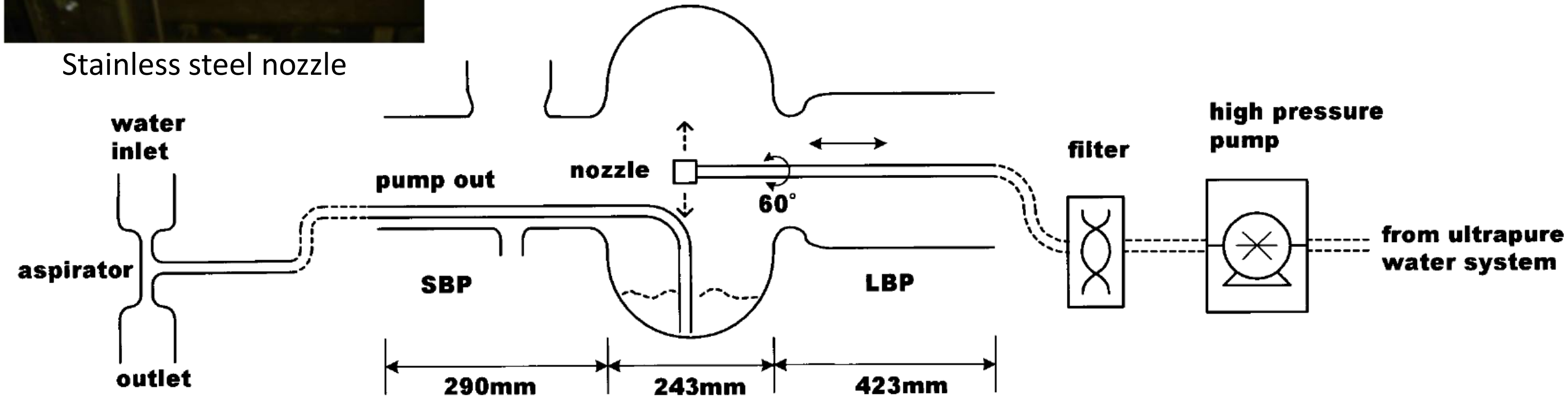
Horizontal high pressure rinsing

- High pressure water rinsing (HPR) is effective to recover degraded cavities contaminated by dust particles
- If we can apply HPR to cavities in cryomodule,
  - Saves a lot of time and costs
- R&D is ongoing
  - Ultrapure water jet (8MPa) from a stainless steel nozzle
  - Wasted water was collected by an aspirator at the equator area
  - Evacuated with residual water

HHPR in our clean room

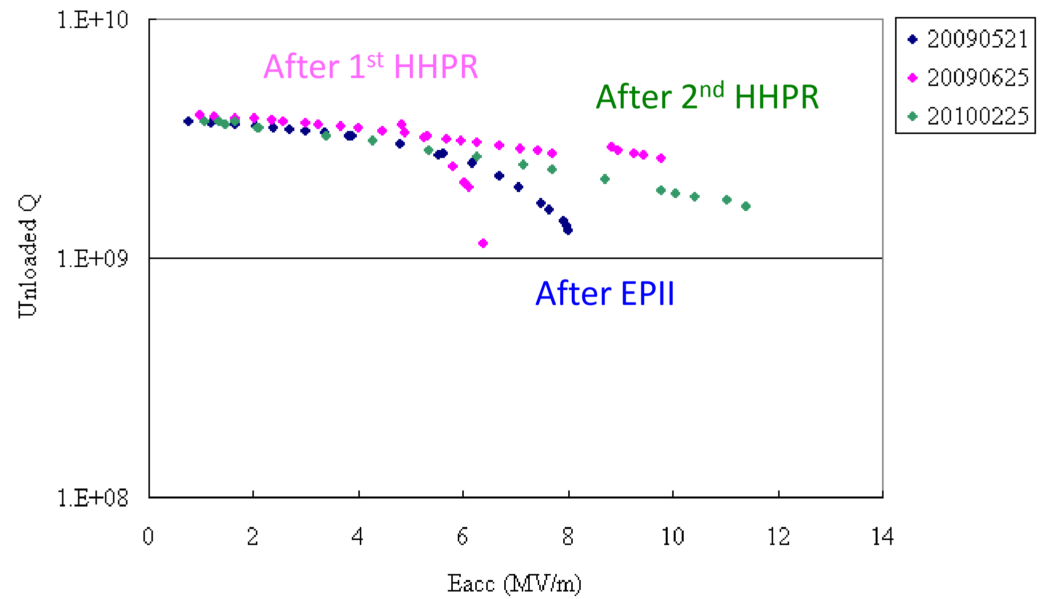


Stainless steel nozzle



RF performance after HHPR

- 2009.3.30 EPII (10µm)
- 2009.4.16 Baked at 120 ℃
- 2009.5.21 Cold test after EPII
- 2009.6.17 HHPR(1st trial)
  - Evacuated in vertical position
  - Residual water dropped on BPF
- 2009.6.25 Cold test after 1st HHPR
  - Without bake
- 2010.2.8 HHPR(2nd trial)
  - Evacuated in horizontal position
  - Residual water stayed in EQ
- 2010.2.25 Cold test after 2nd HHPR
  - Without bake



- Processed once but no degradation
- Applicable for cavity rinsing in a cryomodule

Plan of the next three years

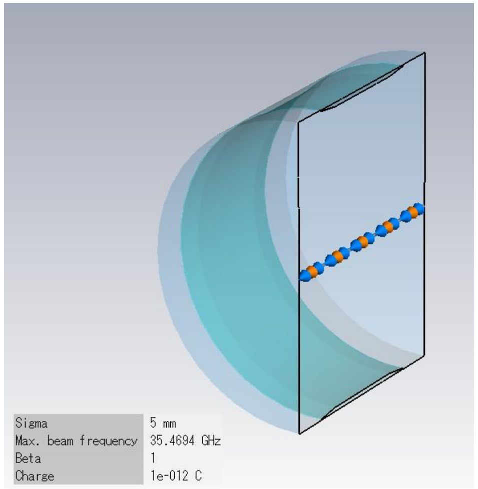
- HOM power handling
  - Stop development of 3 mm thick ferrite dampers
  - Develop 4 mm thick ferrite dampers with a double cooling structure
  - Assemble 200ΦBP and install to the recovered cavity
  - Study SiC dampers to lower ferrite damper loads
- Recovery of degraded cavities
  - Try HHPR in a cryomodule for performance recovery
  - Exchange the recovered cavity with one of degraded cavities

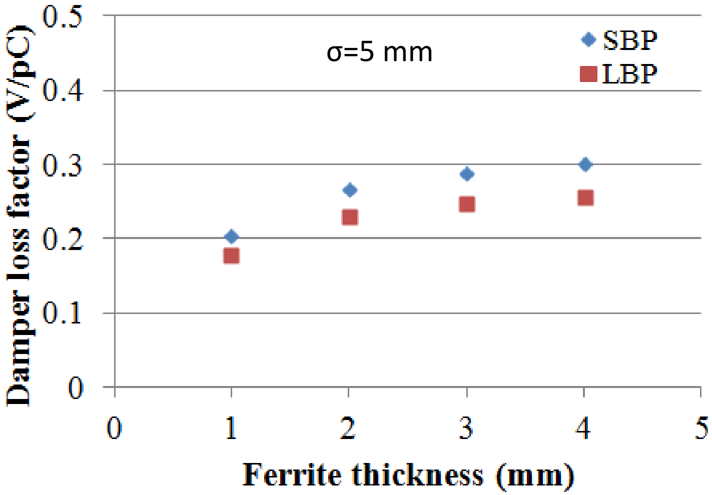
	FY2012	FY2013	FY2014
HOM damper development	High power test for 4mm thick dampers with double cooling structure Study for SiC dampers		
Recovery of degraded cavity (CA-B03) and 200Φ beam pipe	HHPR in cryomodule High power test Assembly of 200Φ BP modules	If not recover HHPR in clean room Cold test EPII (if necessary) Cold test Attach 200Φ BP for low LF High power test	Install in SuperKEKB Cool-down test

backup

Damper loss factor

- Damper loss factors
  - Use CST-PS
  - Calculate 1 to 4 mm thick ferrite dampers
  - Not reduced as expected (8%)

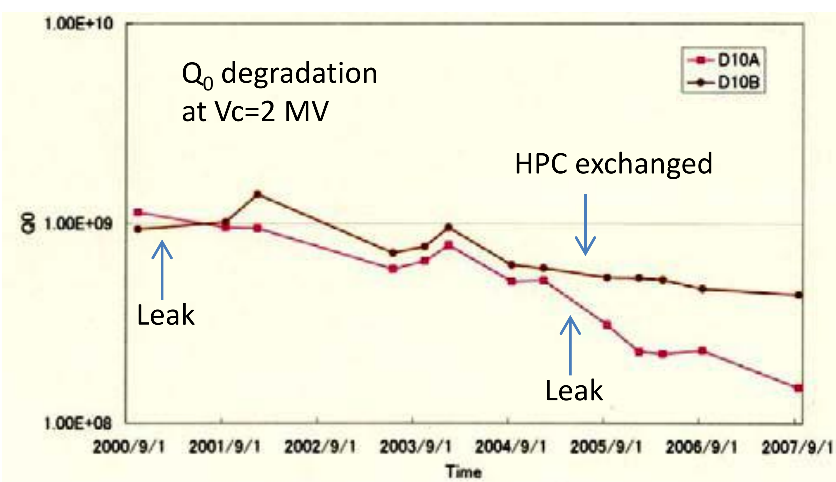




Summary of leaked cavities and Q_0 degradations

Date	Operation phase	Installed place	Cavity ID	Leaked at
1998/10/23	Cool-down	D11B	CA-B03	He vessel, no influence on cavity vacuum pressure Repaired in April, 1999
1999/05/20	Cool-down	D11A	CA-B02	He vessel, no influence on cavity vacuum pressure
Jan. 2001	Warm-up	D10A	CA-B06	Indium seal of LBP, resealed in clean room
Sep. 2001	Cool-down	D11C	CA-B04	Indium seal of LBP, resealed in clean room
2004/01/09	Cool-down	D10C	CA-B08	Indium seal of LBP, resealed in clean room
2004/12/25	In beam operation	D11A	CA-B02	HOM damper flange, HOM damper exchanged Exchanged with CA-B01 in June 2006
2005/07/02	Warm-up	D10A	CA-B06	Indium seal of SBP or LBP, retorqued
2008/07/07	Summer shutdown	D11A	CA-B01	Ion pump connector, retorqued
2010/05/01	Cool-down	D11B	CA-B03	Indium seal of SBP or LBP, retorqued Exchanged with CA-B02 in Nov. 2010

CA-B02
Resealed with 0.5 mm thick indium in Oct. 2006
Metal gaskets exchanged in Dec. 2006
Installed in KEKB in Nov. 2010



High power input couplers exchanged during summer shutdown in 2005