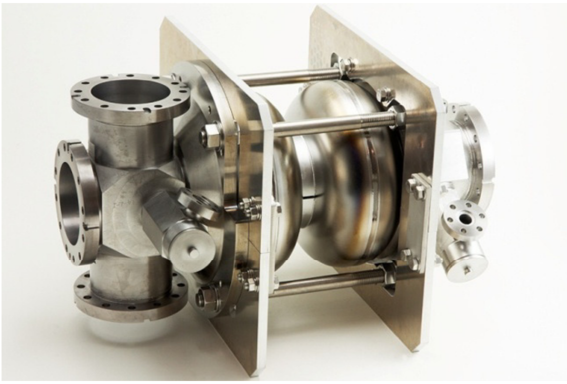
Construction of cERL Cryomodules for Injector and Main Linac



Members for ERL Main linac

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M. Sawamura (JAEA-ERL),

E. Cenni (Sokendai)

Members for ERL Injector linac

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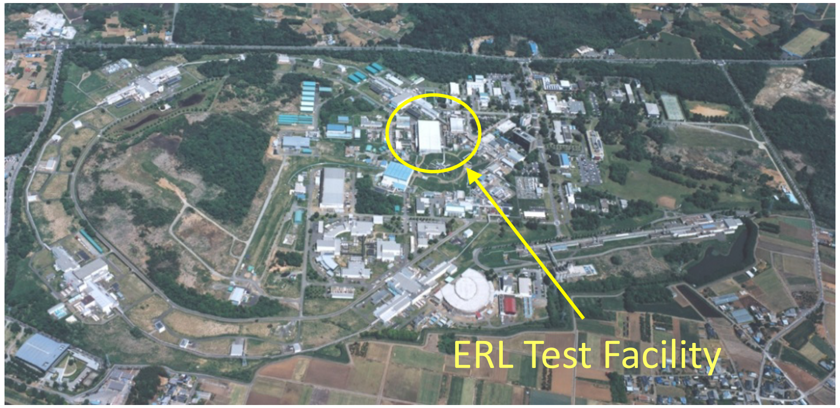
K. Watanabe, Y. Yamamoto (KEK)

Contents

- Compact ERL (cERL) project
- Injector
  - Cryomodule
  - 2-cell cavity
  - Input coupler
  - HOM coupler
- Main linac
  - 9-cell cavity with cavity diagnostics
  - Input coupler
  - HOM absorber
  - Cryomodule
- Summary

The Compact ERL(cERL) for demonstrating ERL technologies

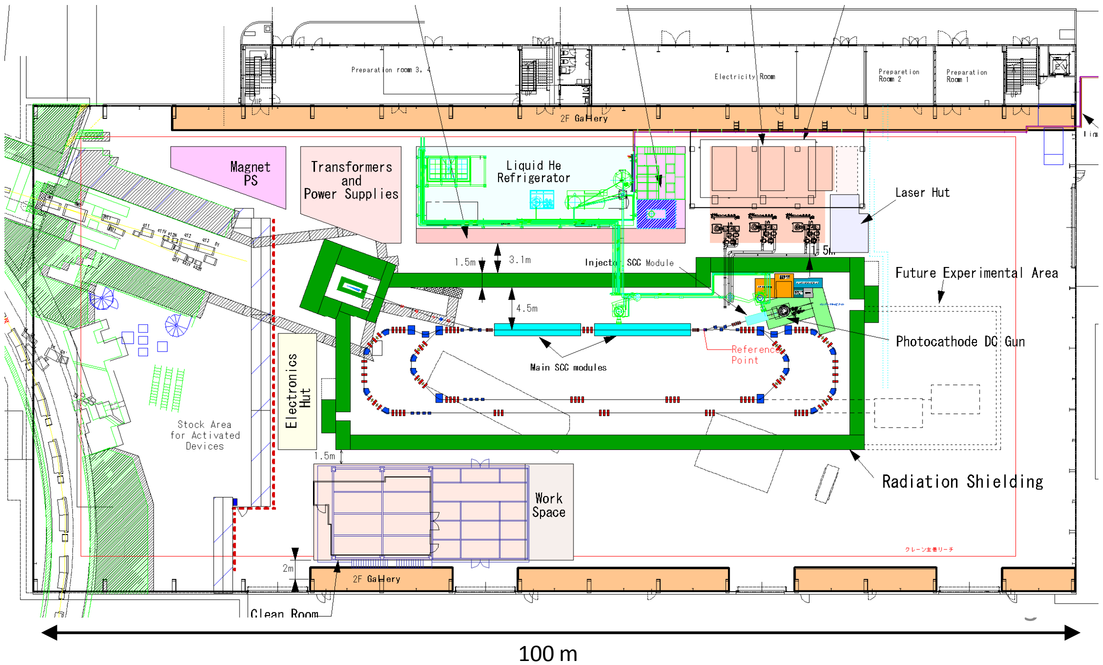
Before constructing large-scale ERL facility, we need to demonstrate the generation of ultra-low emittance beams using key devices. ➡ Compact ERL



Parameters of the Compact ERL

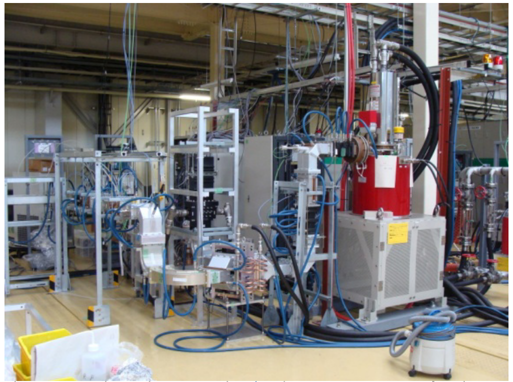
	Parameters
Beam energy	35 - 245 MeV
Injection energy	5 MeV
Average current	10 - 100 mA
Acc. gradient (main linac)	15 MV/m
Normalized emittance	0.1 - 1 mm·mrad
Bunch length (rms)	1 - 3 ps (usual) ~ 100 fs (with B.C.)
RF frequency	1.3 GHz

※ blue numbers are parameters for initial stage



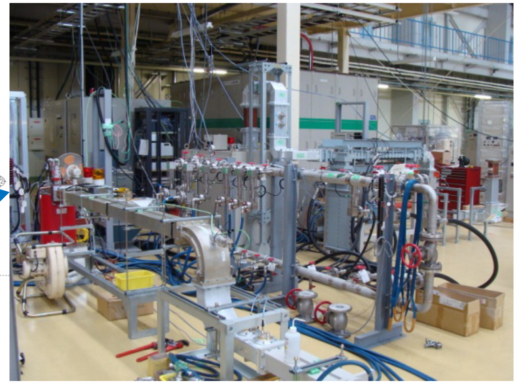
Current status of ERL Test Facility

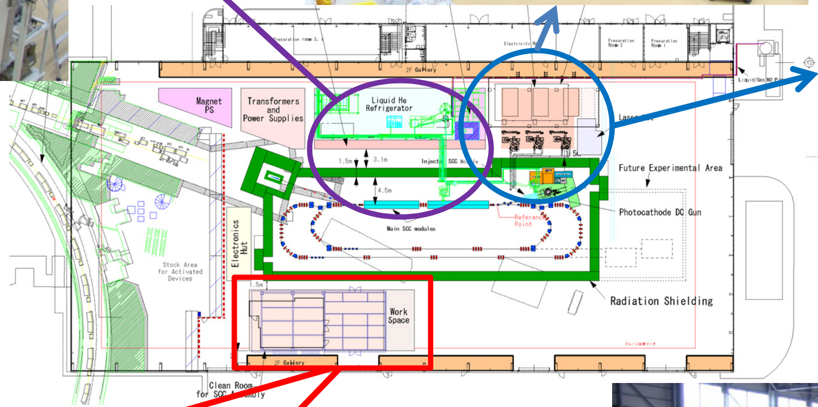
2K refrigerator system



300 kW klystron

30 kW klystron and IOT

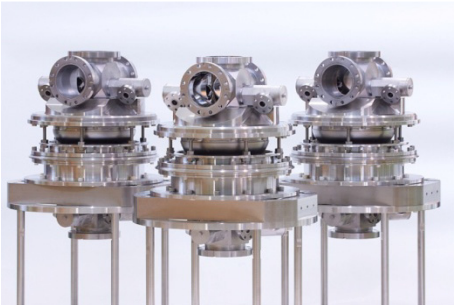


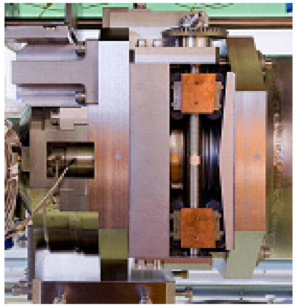


Cleanroom for module assembly

ERL Test Facility from top of cleanroom

Cryomodule for cERL injector

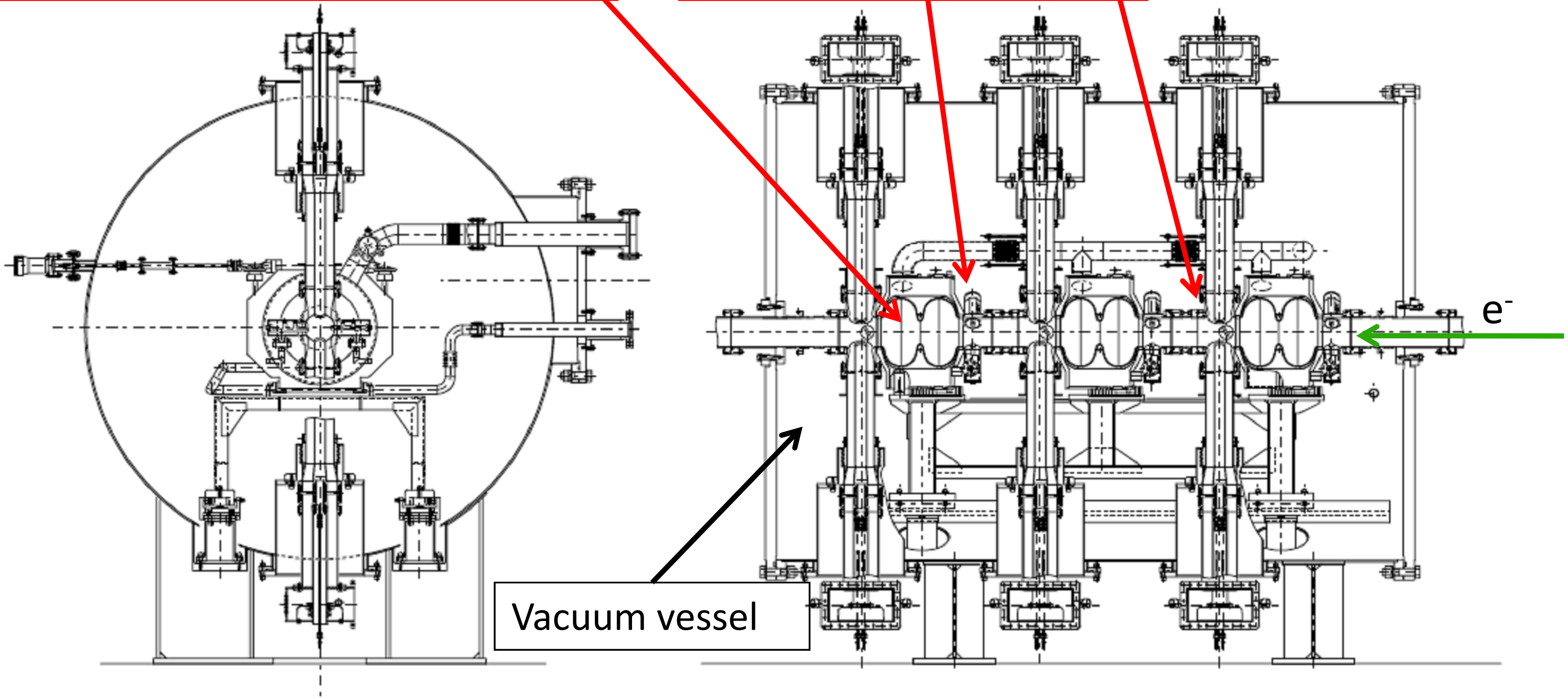




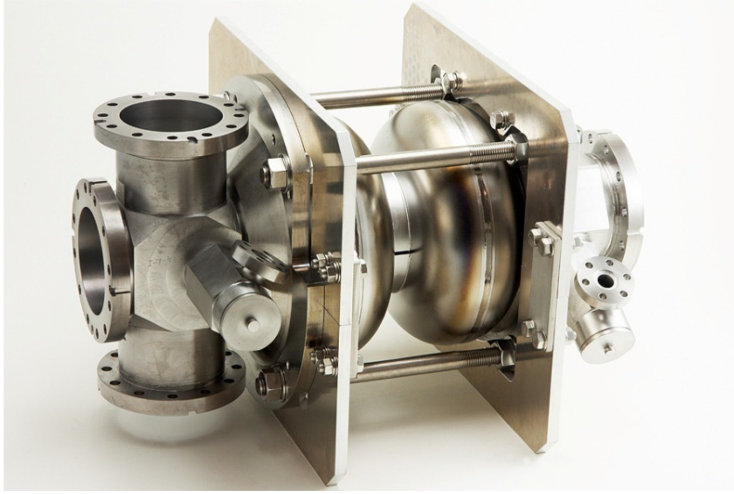
Input coupler
double feed
167kW/coupler

Cavity : 3 x 2-cell cavities
Slide-Jack tuner and piezo tuner

5 loop-type HOM couplers for one cavity

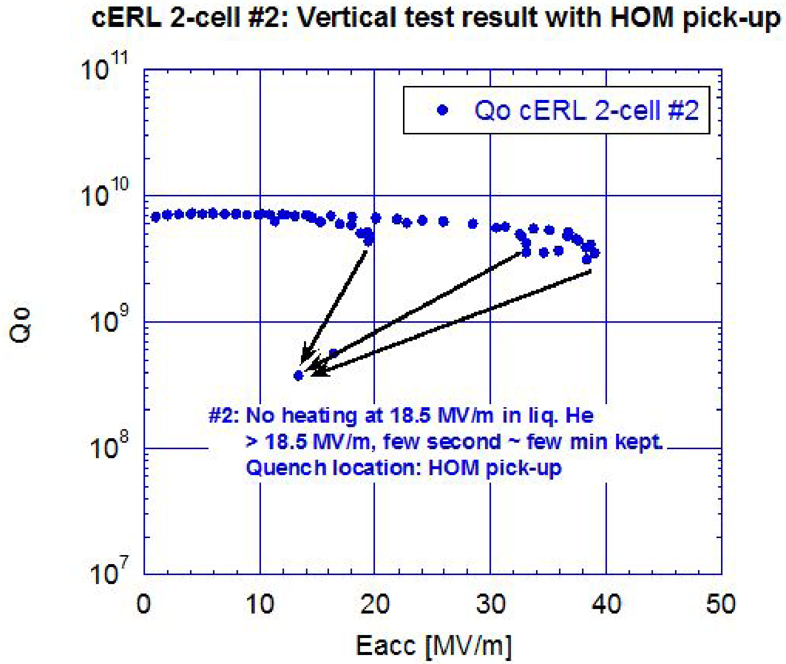


2-cell injector cavity



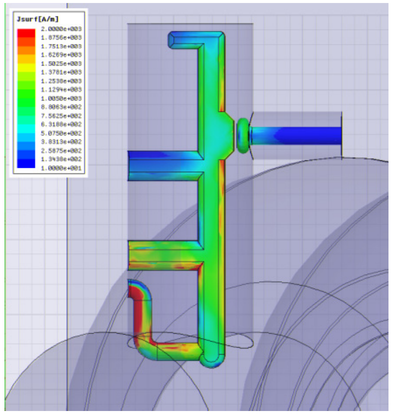
- 2-cell cavity with TESLA-like cell shape and enlarged beampipe
- Operation around 15 MV/m
- 5 loop-type HOM couplers per one cavity
- Fabricate #1, #2 prototype cavities and #3, #4, #5 cavities for operation

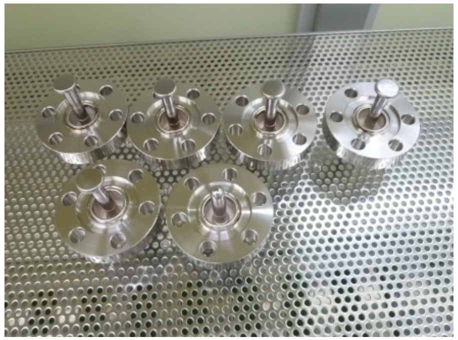
Vertical test results for #2 cavity



- Heating occurred at HOM pickup probe
- Hard to keep high field at CW

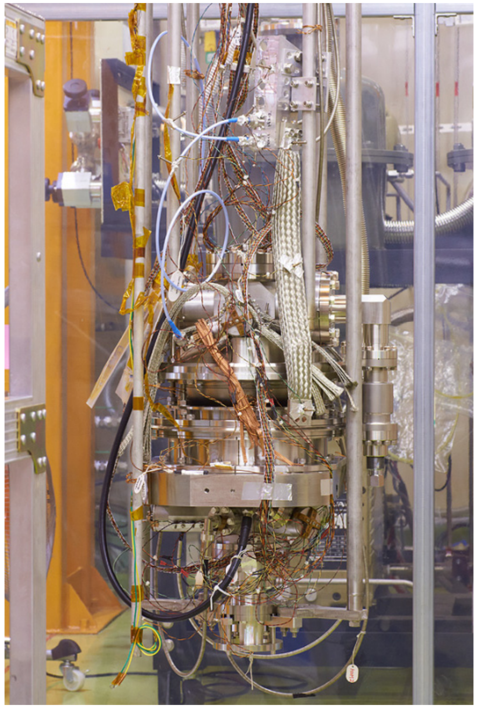
HOM coupler



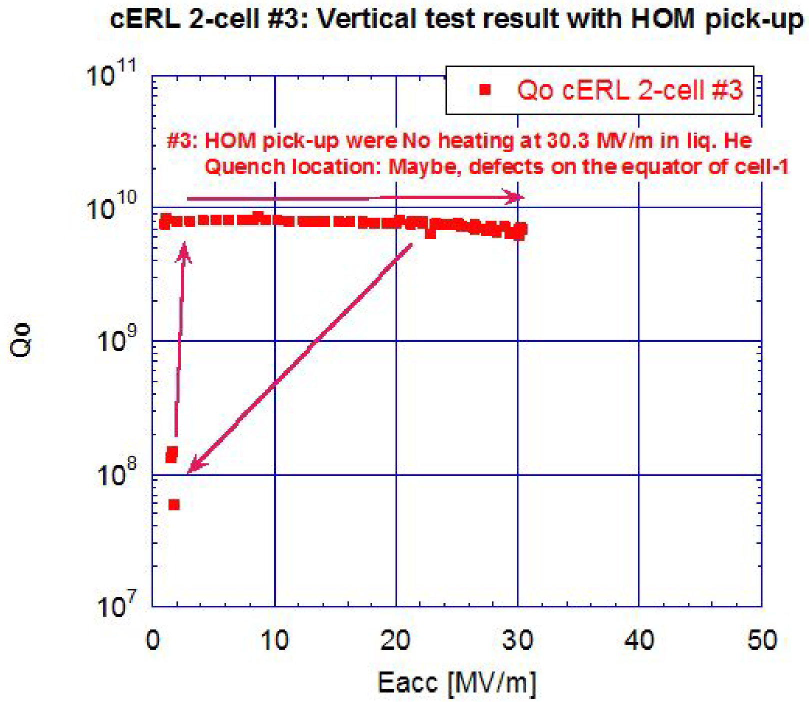


- Design is based on TESLA loop coupler
- Have heating problem for CW operation
- Added high pass filter to reduce magnetic field at tip of pickup antenna

Cooling of HOM coupler and cavity #3 VT results



Setup of vertical test
for 2-cell cavity



Enhanced cooling of HOM pickup

・Thermal anchor around HOM pickup connector.

・Thermal connection of antenna was improved using Indium seal.

・Polish antenna surface

• Field could be kept to be > 25 MV/m at CW, with the condition HOM coupler was out of He.

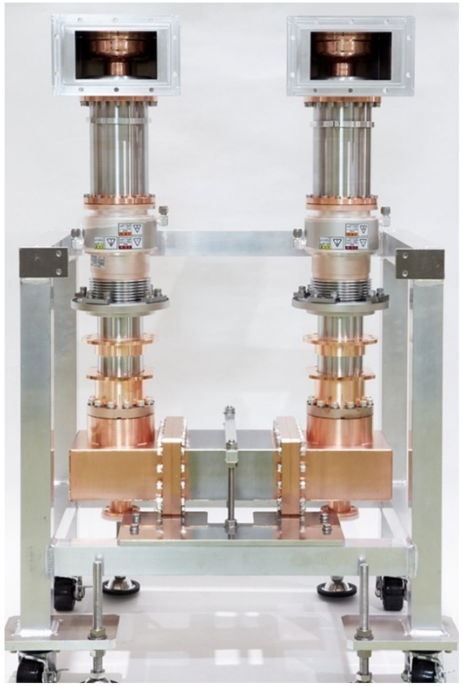
→ Enough for CW use of cERL.

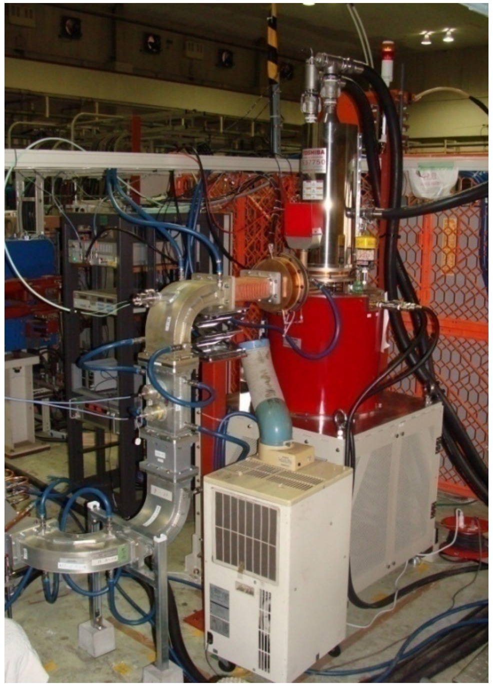
• Further cooling study is on going
• Some R&Ds are going for connector

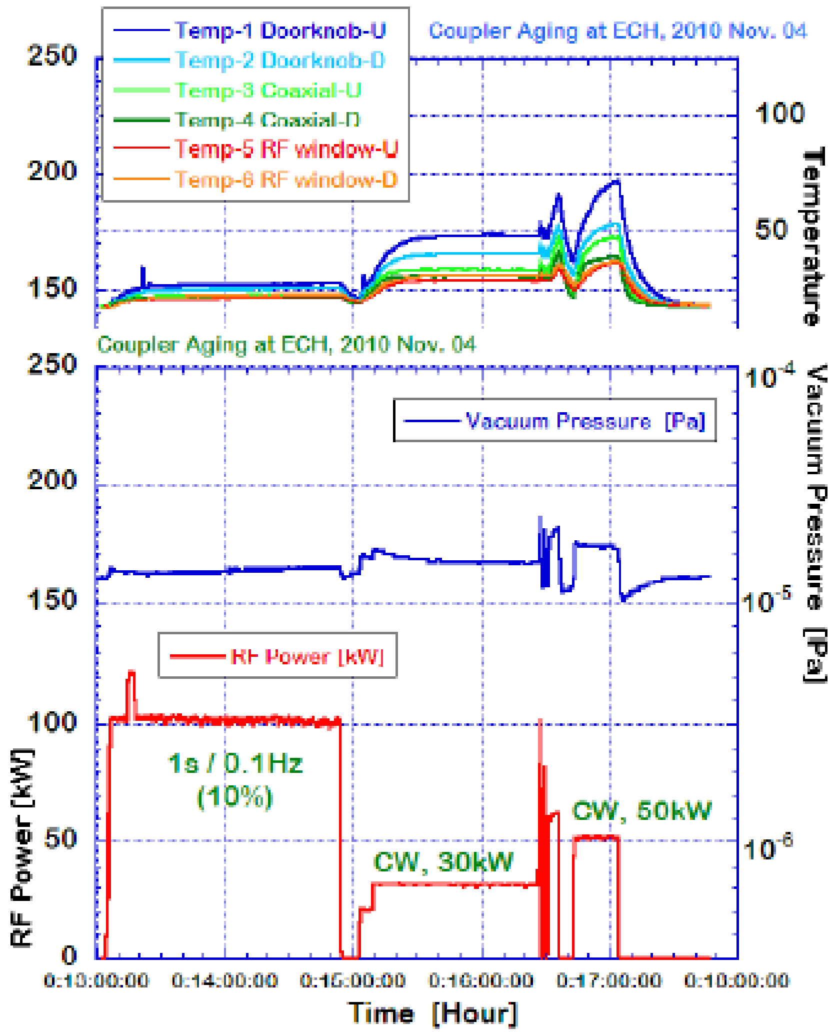
input coupler

See FRIOA05
H. Sakai

- High current, 100mA, CW operation
  →100mA X 10MV = 1MW!
  →167kW/coupler with total 6 coupler
- Inner conductors and windows are water cooled.
- High power tests are performed, using 300 kW klystron.







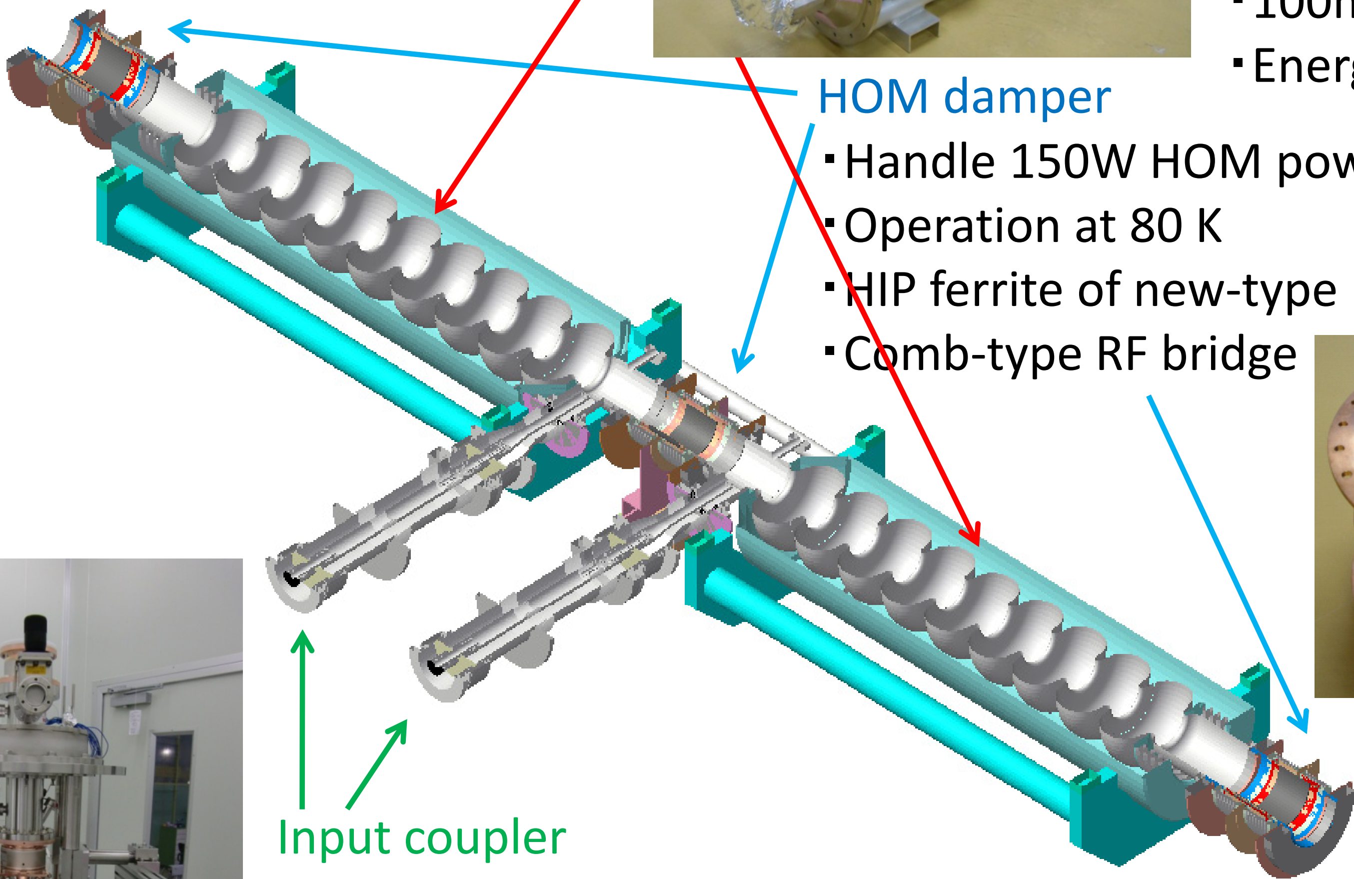
Results of conditioning

- 1 sec, 0.1Hz, 100kW (2 hours)
- CW 30 kW (1.5 hours)
- CW 50 kW (0.5 hours) with some heating
- CW 100 kW (1 minute)

ERL main linac

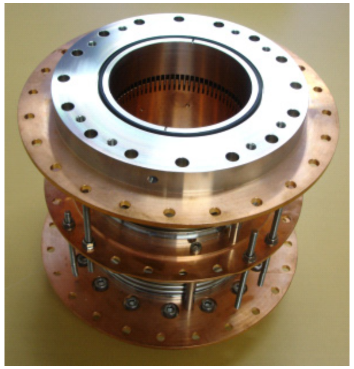
9-cell cavity

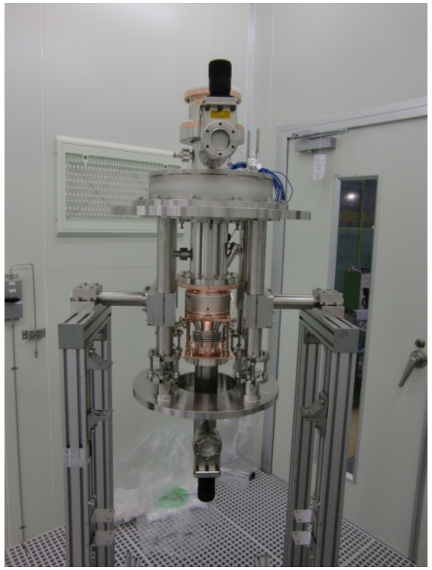
- HOM damped cavity shape
- Eacc=15-20MV/m
- 100mA CW
- Energy recovery



HOM damper

- Handle 150W HOM power
- Operation at 80 K
- HIP ferrite of new-type IB004
- Comb-type RF bridge





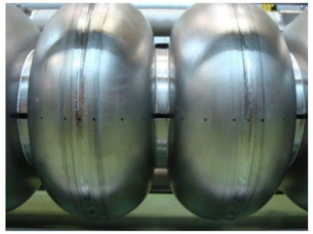
Input coupler

- 20kW CW (total reflection)
- Cold and warm window
- HA997 ceramic is used
- High power tests are performed

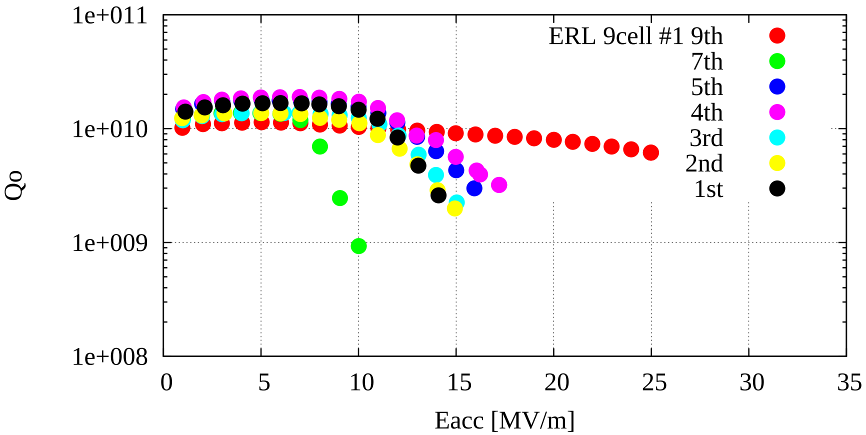
First module with two cavities for cERL project

See poster
THPO034 E. Cenni

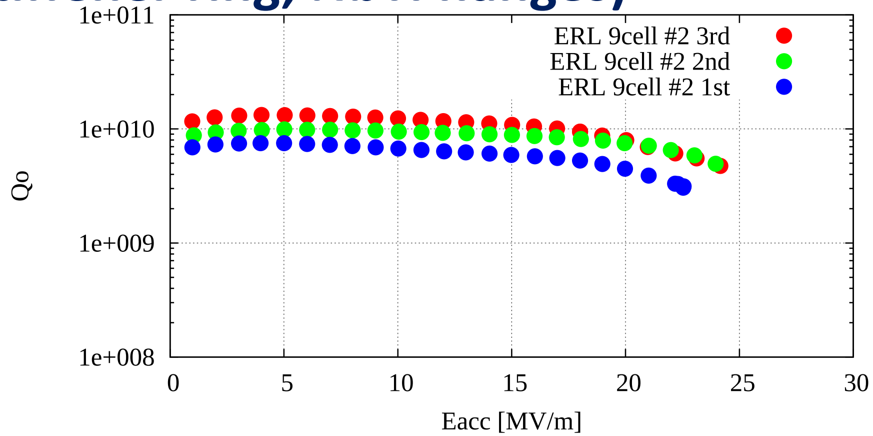
Results of vertical tests



#1 ERL 9-cell cavity



#2 ERL 9-cell cavity (With Ti endplate, stiffener ring, NbTi flanges)

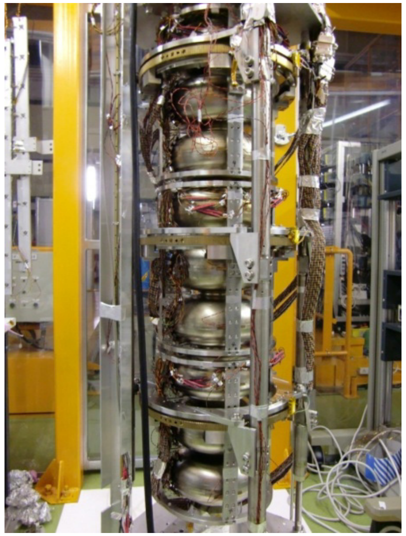


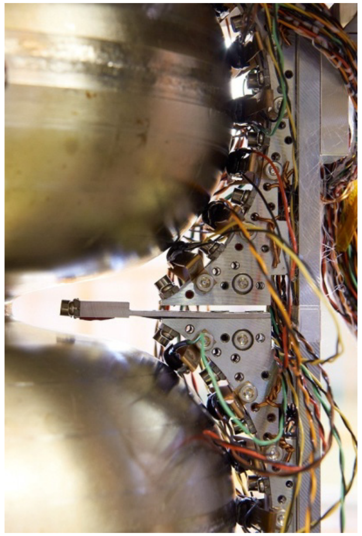
- Severe field emissions were observed
- Maximum Eacc was limited to 15 ~ 17 MV/m, until 7th measurements.
- At last, we got nice results, > 20 MV/m at 9th measurements.

- Can reach to > 20 MV/m for both tests
- Field emissions were not so large

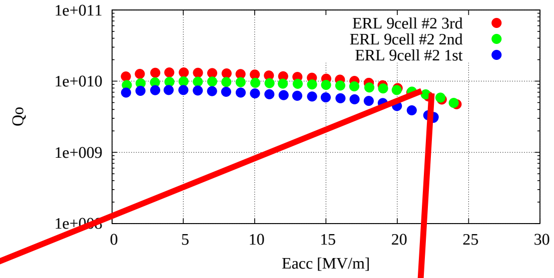
low Q value is due to SUS flanges, used after 5th measurement of #1 cavity
low Q value #2 cavity 2nd VT was recovered at 3rd VT, by just warming-up

Cavity diagnostics

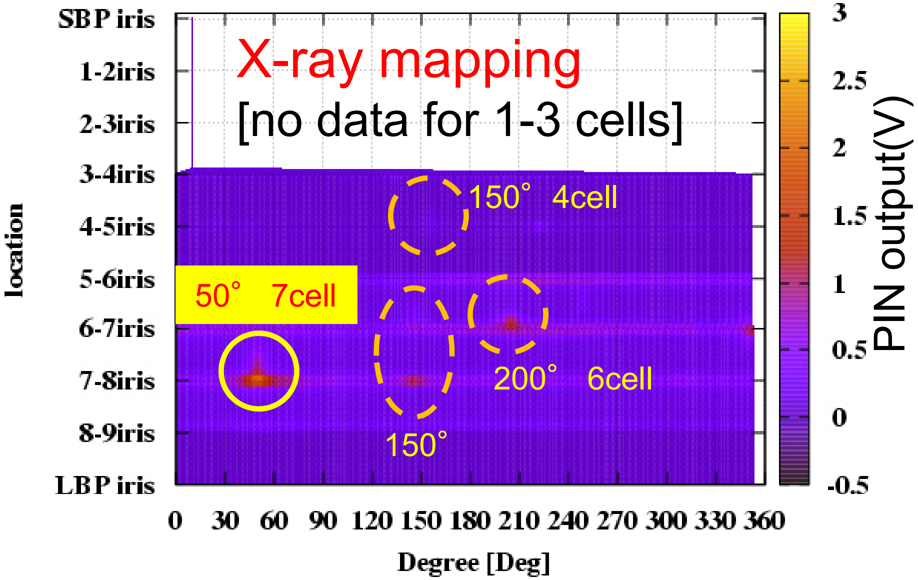


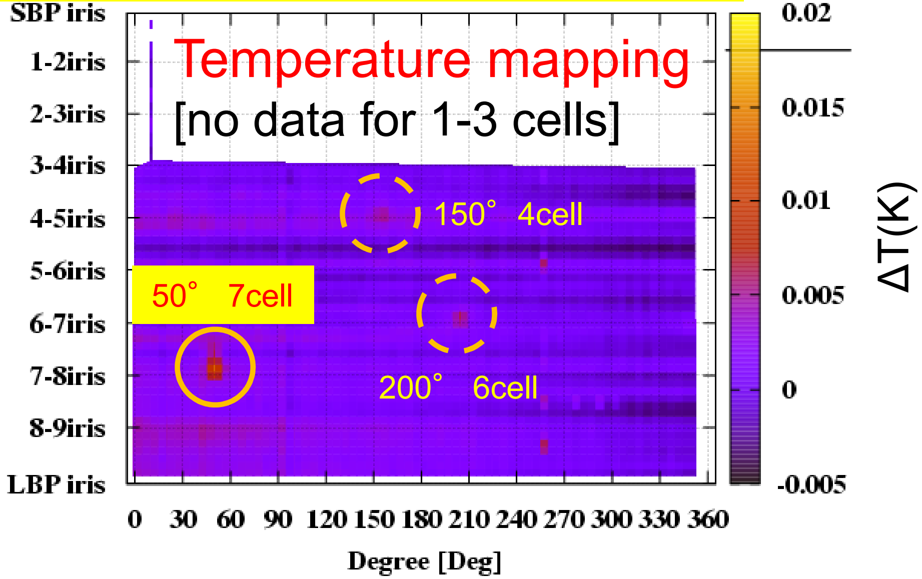


- Array of Si diode for X-ray detection and carbon resistor for temperature measurement
- They will rotate around cavity by using pulse motor



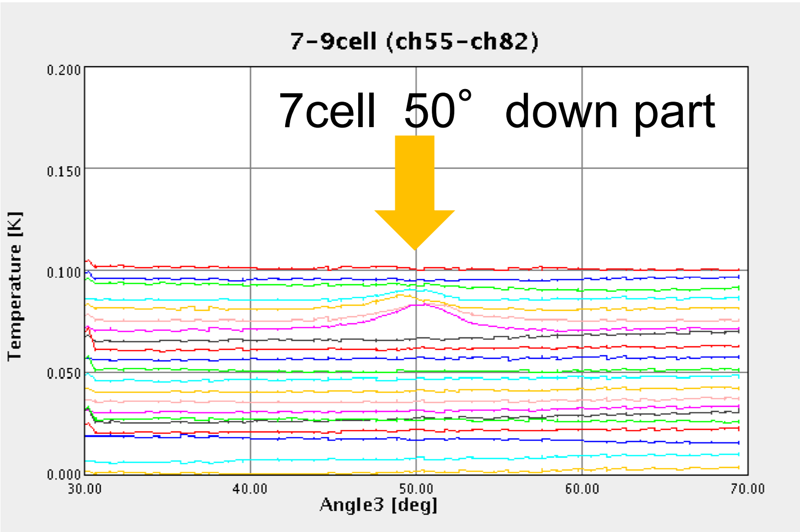
3rd VT for #2 cavity initial pi-mode (23MV/m)



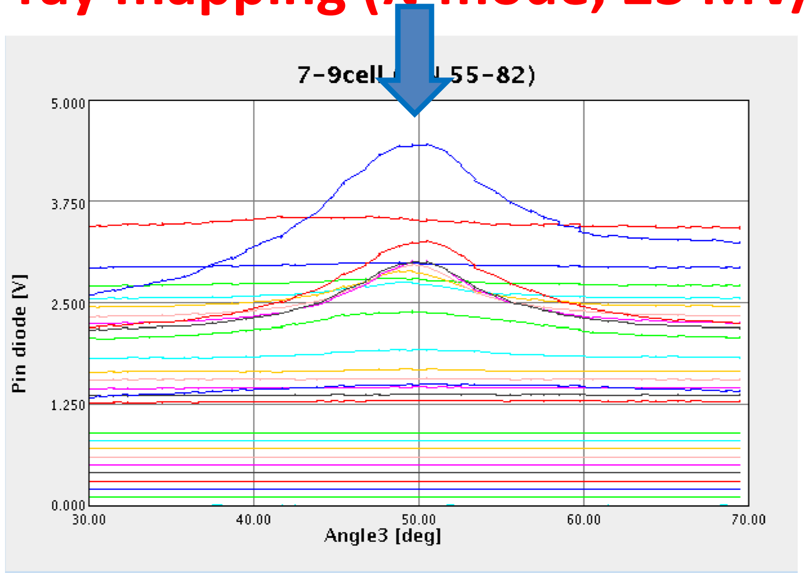


(Comment) Mapping data at pass-band mode give us rich information

T-mapping (π-mode, 23 MV/m)



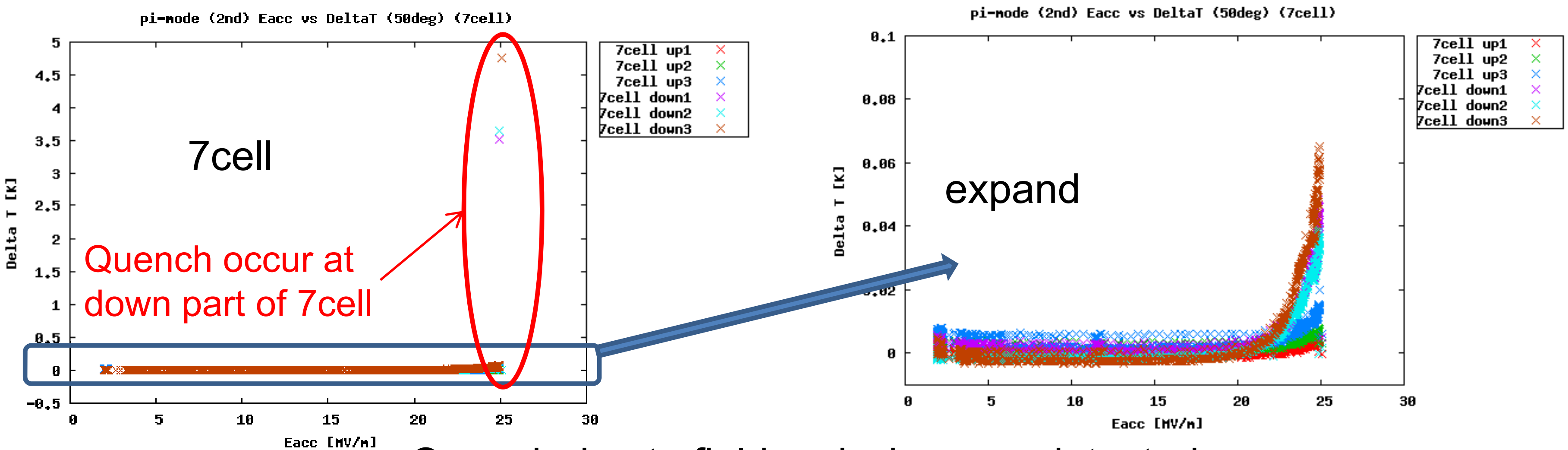
X-ray mapping (π-mode, 23 MV/m)



Observed X-ray trace and also temperature rise at same position!

<u>Temperature rise at quench （#2 cavity, 3rd VT, π-mode, >25MV/m)</u>

Eacc vs Delta T (pi-mode 2nd) (50deg) (7cell & 8cell)

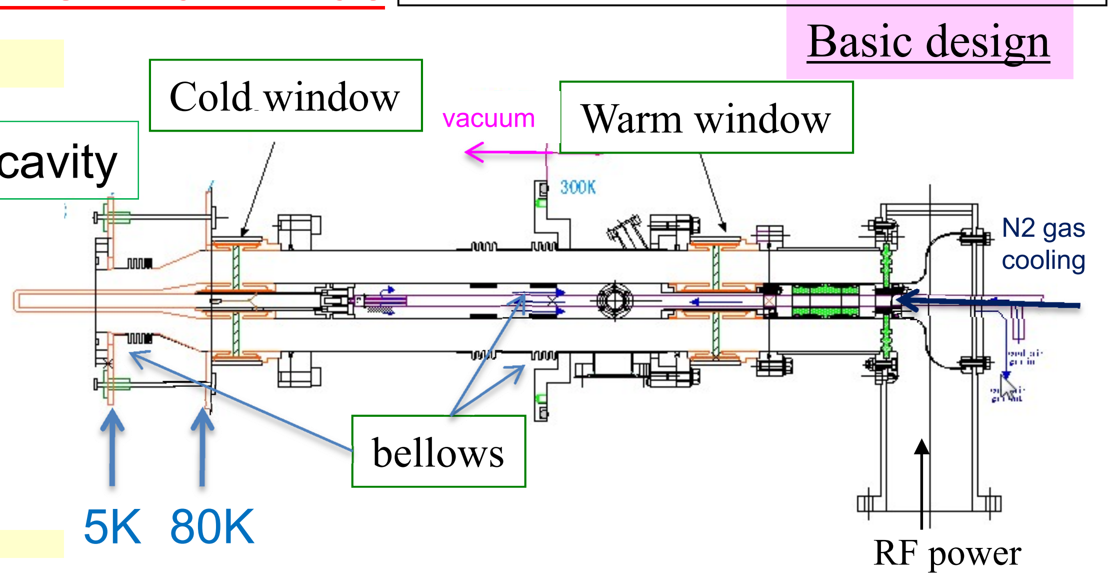


Quench due to field emission was detected

Development of input coupler for main linac

See TUPO005, FRIOA05 H. Sakai

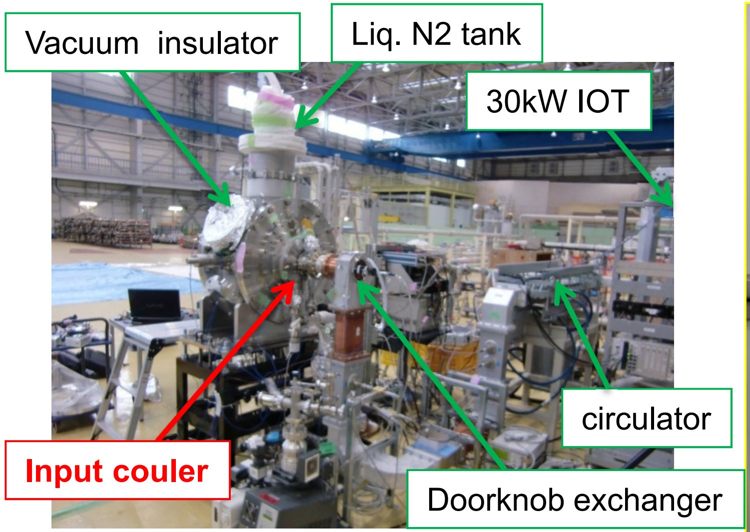
- Basic parameters
  - frequency : CW, 1.3GHz
  - Accelerating gradient : Max 20MV/m
  - input power : max 20kW , standing wave
  - loaded Q(Q_L) : (1-4) * 10^7 (variable coupling)
- Points
  - Forced N2 gas cooling of inner conductor
  - Impedance 60Ω
  - 99.7% pulity of ceramic window are used.



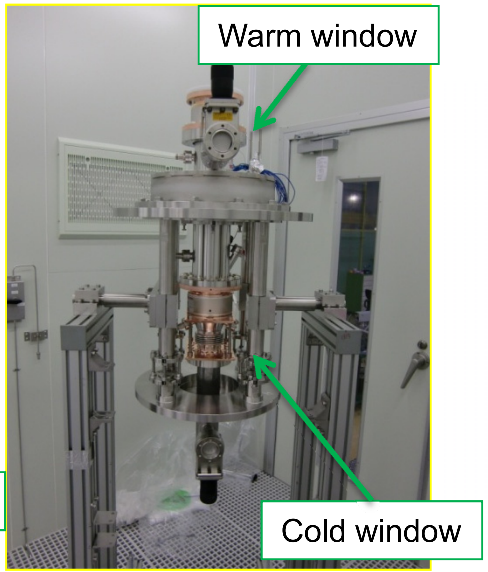
・High power test of prototype of input coupler under liquid Nitrogen cooling with vacuum insulator

Can keep 20kW power for 16hours with standing wave.

Finally achieve 25kW power feeding with standing wave.

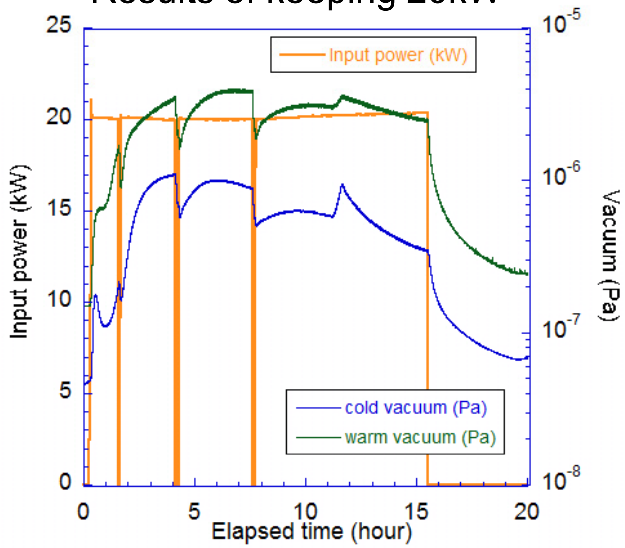


High power test setup with liquid Nitrogen



Prototype of input coupler

Results of keeping 20kW



Sudden power down is mainly
Caused by noise of arc sensor.

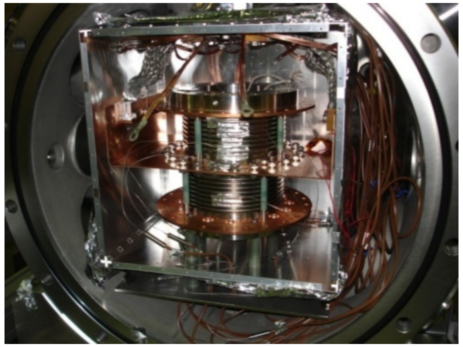
See poster
TUPO003 M.Sawamura

HOM absorber

- HIP ferrite of new-type IB004
- Comb-type RF bridge

Cooling test at 80K

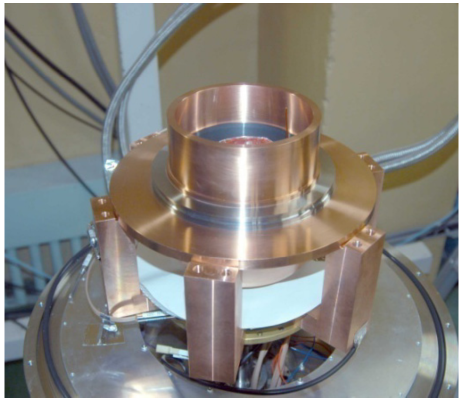
(using prototype without ferrite)



- Cooling ability against 100W HOMs was tested under 80K condition.
- Generally, it went well.
- Modification for Comb-shape to reduce thermal transmission.

Heat cycle test (RT – 80K)

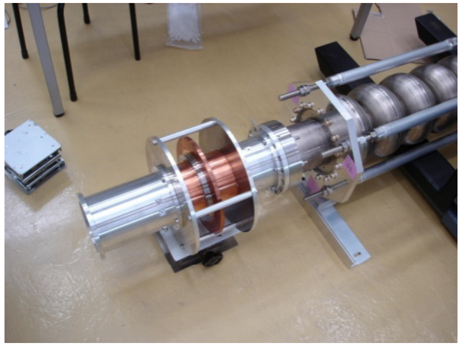
(using prototype with ferrite)

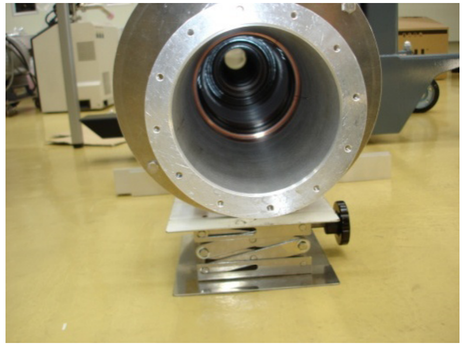


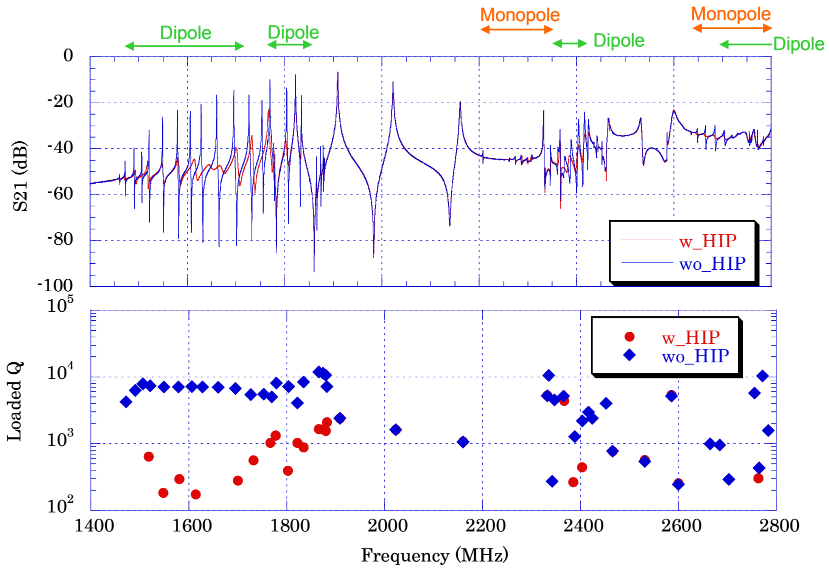
- Heat cycles, between RT to 80K, were applied to prototype HOM absorber.
- Some cracks were observed
- Details are under inspection

HOM measurement at RT

(using prototype with ferrite)

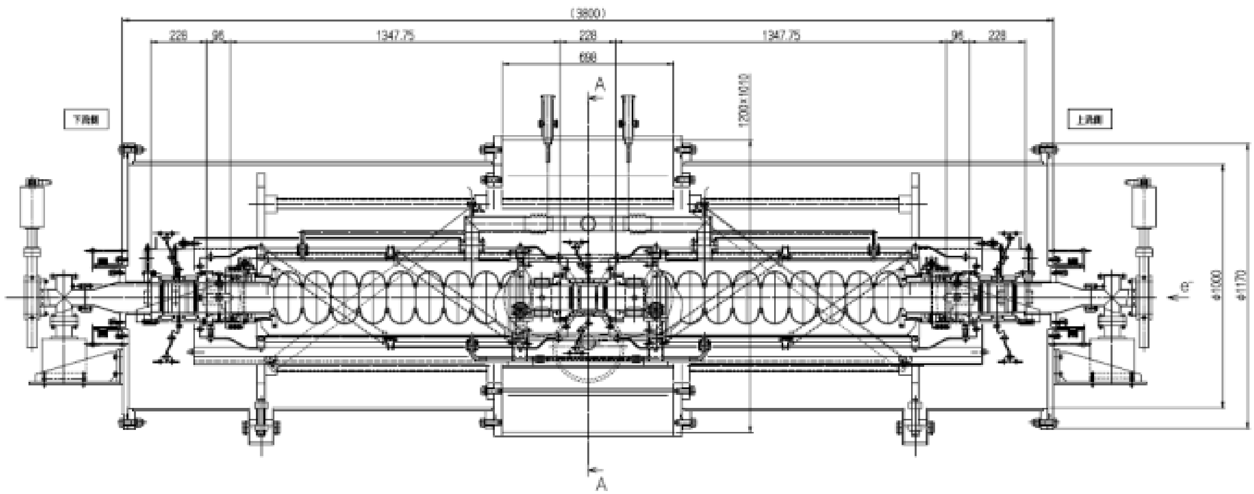






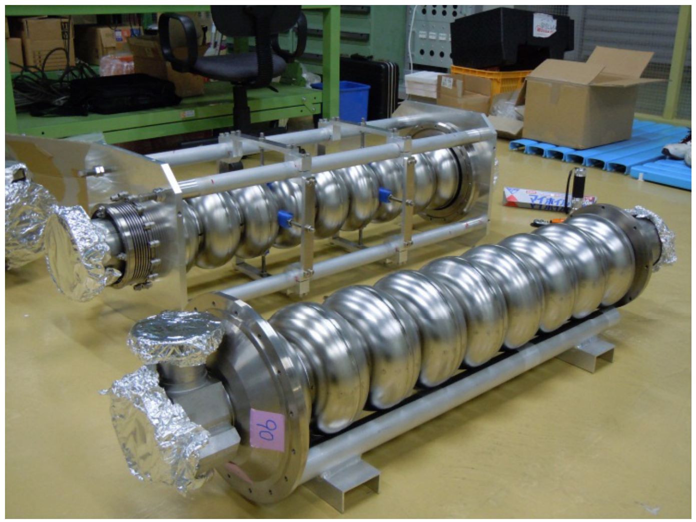
- Mounted on LBP side of #2 cavity, and measured at room temperature
- HOMs are sufficiently damped.

Cryomodule for main linac

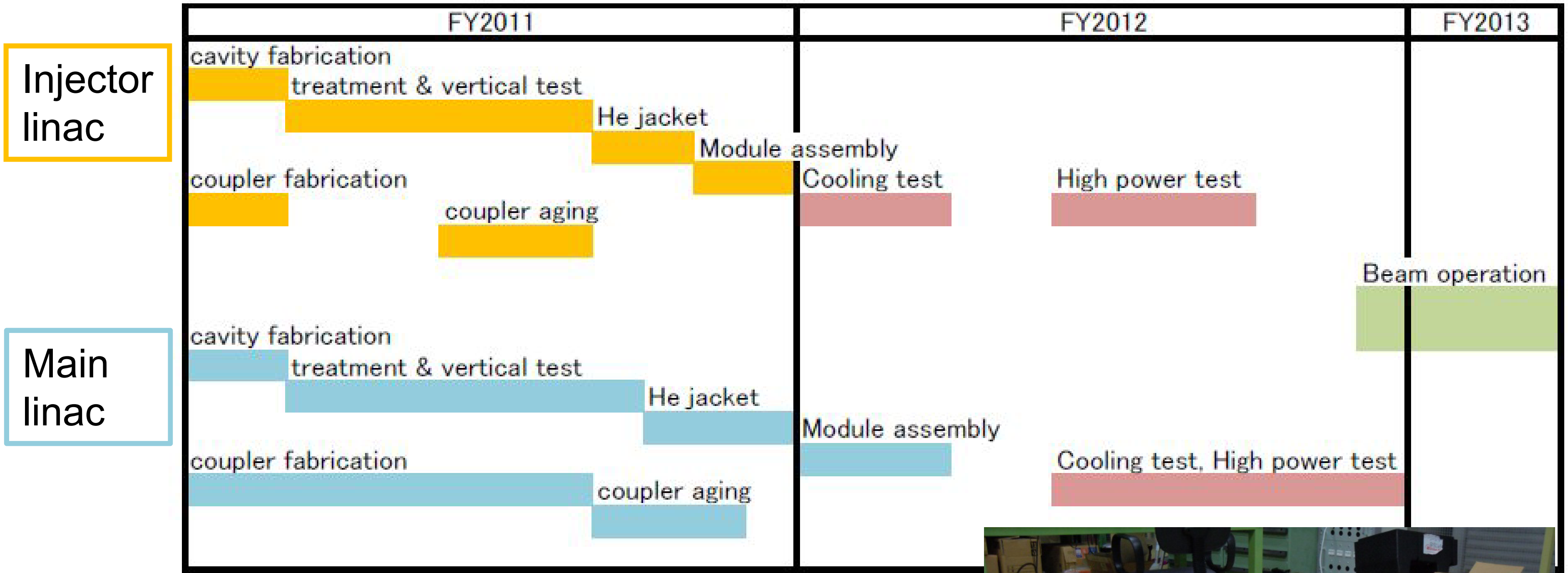


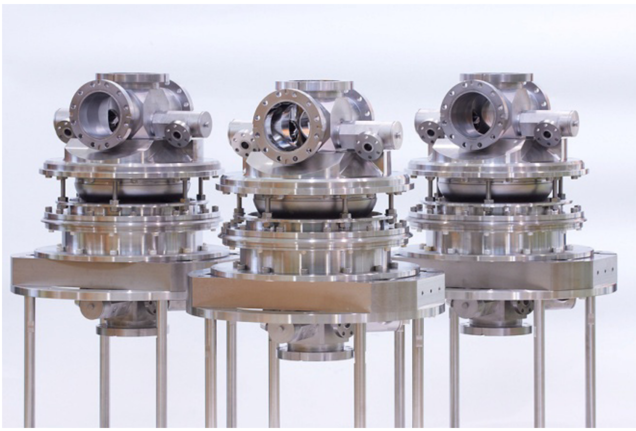
- Cryomodule is under construction.
- Two cavities were fabricated. They are under surface treatment

  → Vertical test from this autumn
- Two input couplers and three HOM absorbers are under fabrication.
- Slide-Jack type mechanical tuner and piezo tunes are applied
- Cryomodule will be assembled next year



Schedule


FY2011
FY2012
FY2013
Injector linac
cavity fabrication
treatment & vertical test
He jacket
Module assembly
coupler fabrication
coupler aging
Cooling test
High power test
Beam operation
Main linac
cavity fabrication
treatment & vertical test
He jacket
Module assembly
coupler fabrication
coupler aging
Cooling test, High power test



Summary

- cERL is under construction at ERL Test Facility in KEK.
- Injector linac
  - Cavity is ready. Heating problem at HOM pickup was improved and > 25 MV/m was achieved for CW operation.
  - Input coupler successfully passed 50 kW of CW power. For 100 kW and more, cooling should be improved.
- Main linac
  - Cavity reached to > 20 MV/m
  - Input coupler passed > 20 kW standing wave.
  - Several tests were done for HOM absorber.
- Both cryomodules will be constructed during 2012. After cooling test and high power test, beam operation will start.