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Conditioning and Operation of HWRs for C-ADS Injector

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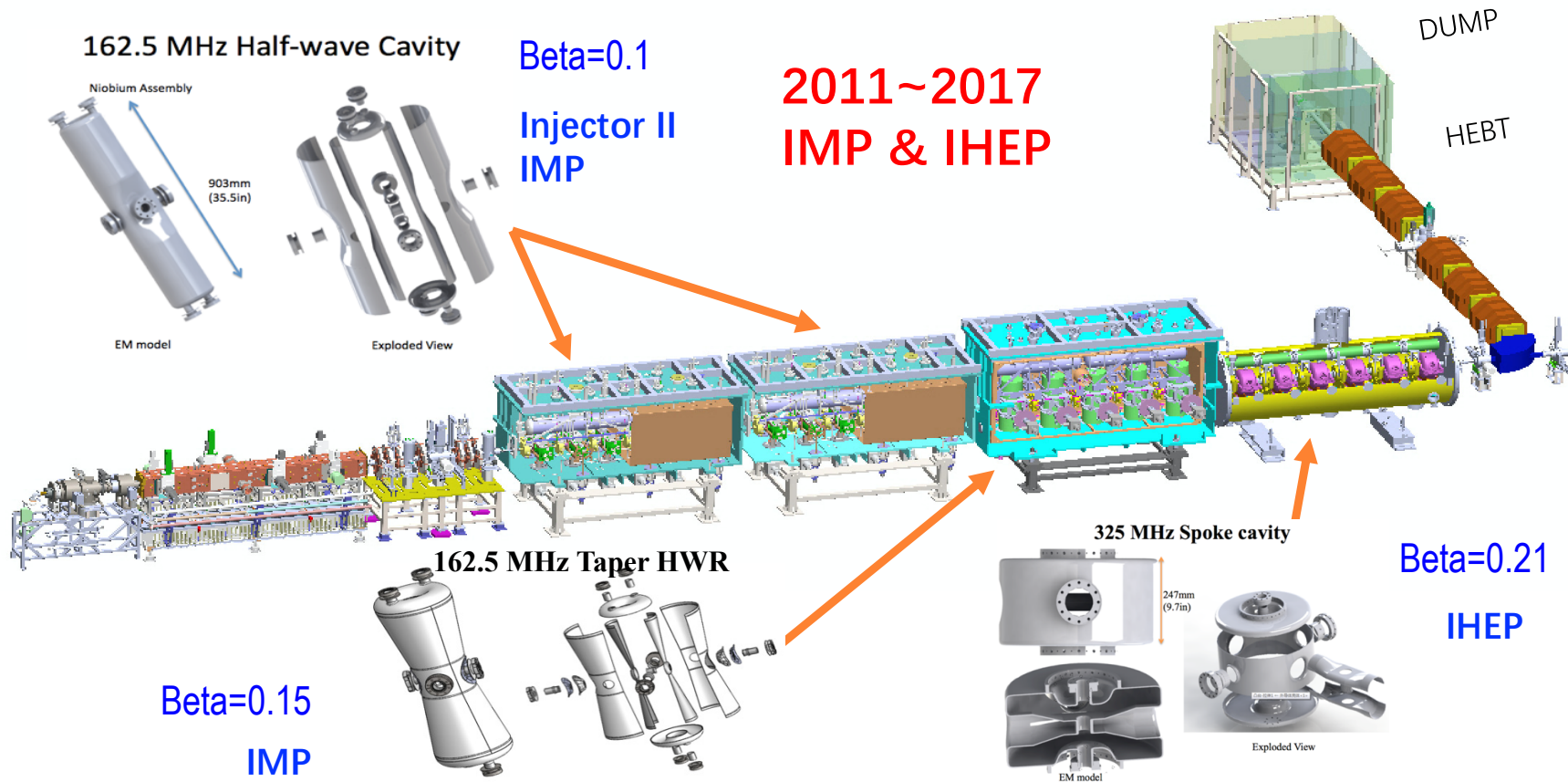


Outlines



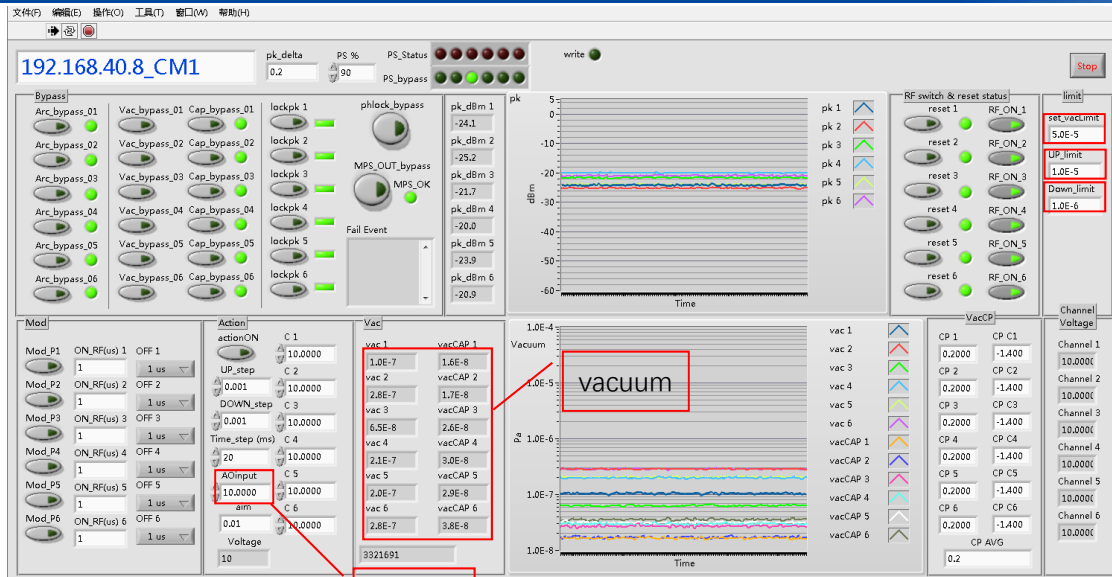
- Overview of the HWRs development in IMP
- HWRs and couplers conditioning
- HWRs operation
- Summary

Overview of the HWRs development in IMP





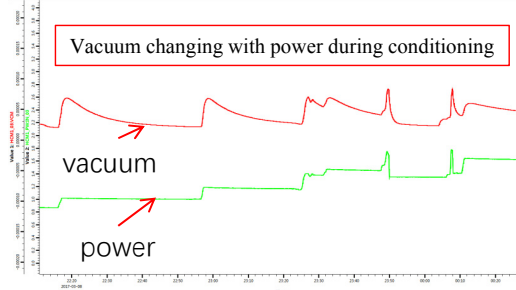
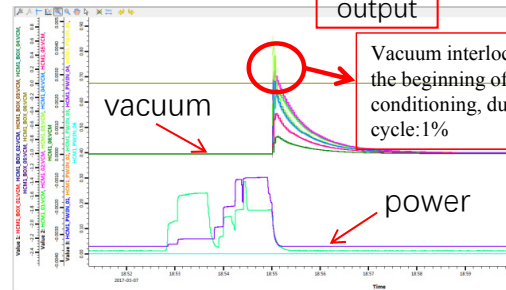
Issues of couplers RF Conditioning in 300 K



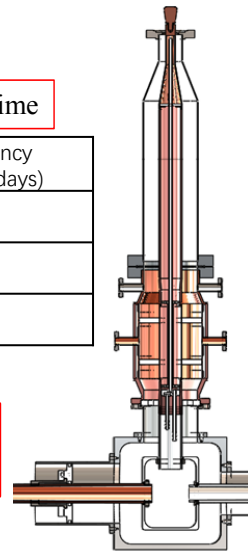
- Offset the HWR resonant frequency
- Set signal source frequency to 162.5MHz
- Test interlock
- Monitor the temperature of the coupler and cavity, Monitor the vacuum
- Pulse mode conditioning: 1%, 2%, 1%, 5%, 20%, 50%, 90%, CW
- Frequency sweeping, ± 2 kHz
- Test the conditioning result

Summary of the coupler conditioning time

	pulse mode(days)	CW mode(days)	frequency sweep(days)
CM1	8	2	2
CM2	7	3	1
CM3	7	3	2



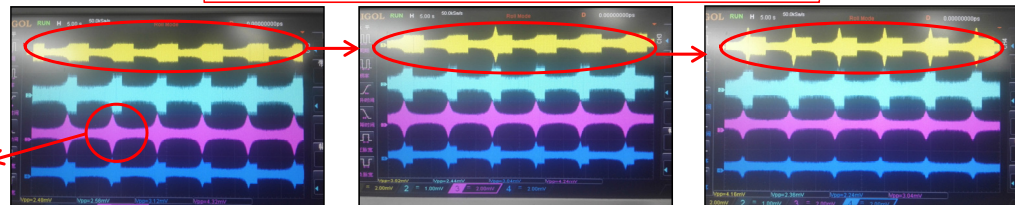
Several points are difficult to condition. Solved by use of bias!



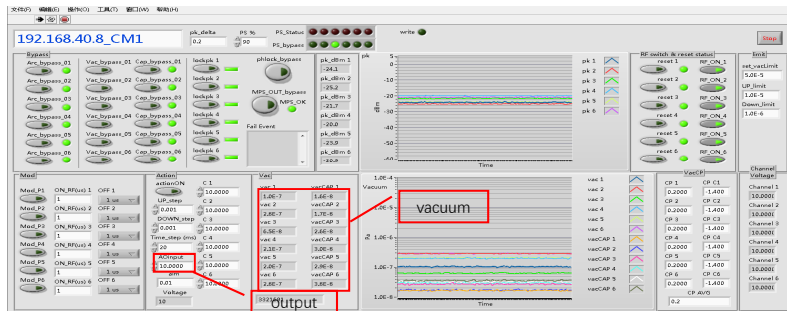
Issues of HWRs RF Conditioning in 4K

- Test interlock
- Condition with signal source frequency sweeping
- Pulse mode conditioning: 1‰ (1 ms/s), 2‰, 1‰, 5%, 10%, 20%, 50%, 75%, 90%, CW
- Test with close loop
- Monitor the vacuum, X-ray and temperature

conditioning with signal source frequency sweeping

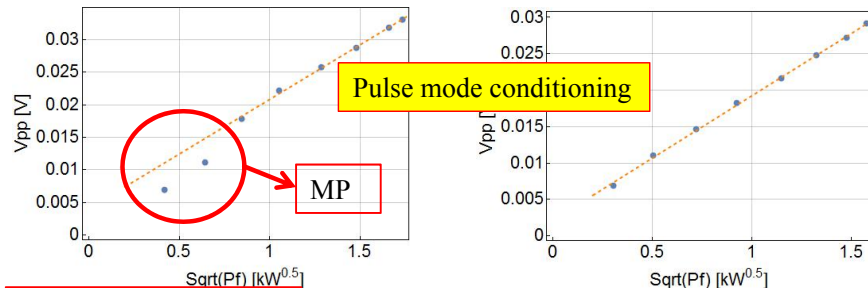


no MP



vacuum

output



Pulse mode conditioning

MP

Limit by voltage limiter

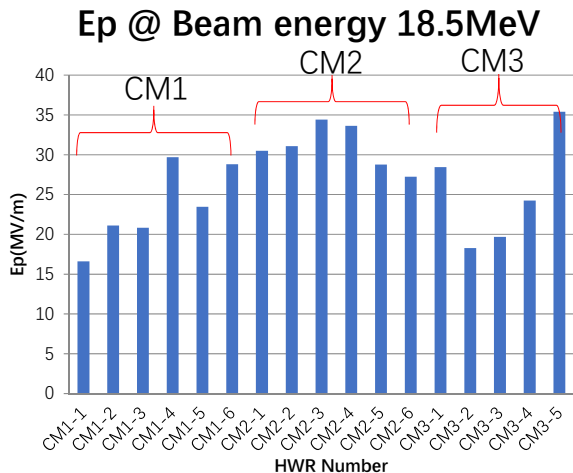
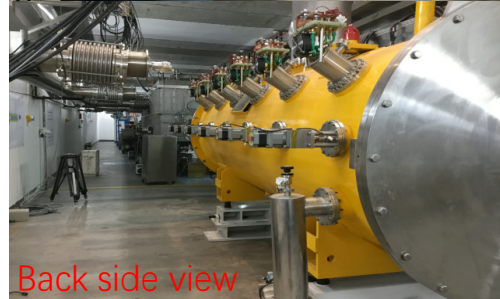
Ponderomotive instabilities

GDR mode

SEL mode

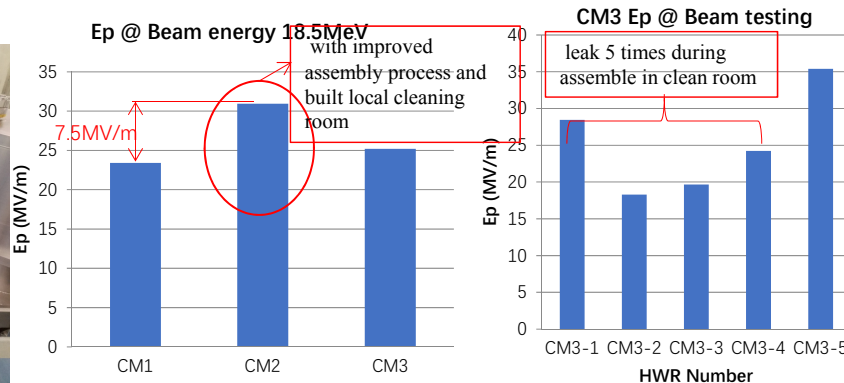
Summary of the cavity conditioning time

	frequency sweep(days)	pulse mode(days)	CW mode(days)
CM1	8	11	4
CM2	8	11	4
CM3	3	9	2



HWRs gradient limit by field emission

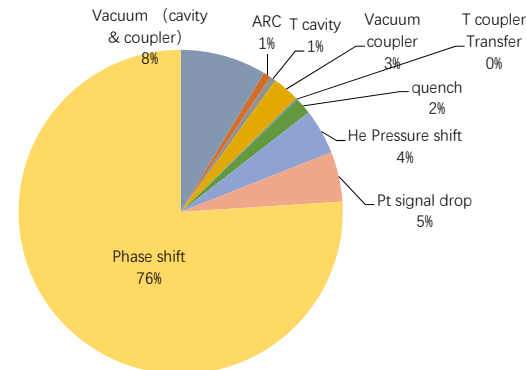
- CM1+CM2: accelerate beam 2.1-10MeV; CM3: accelerate beam 10-18.5MeV (beam)
- The average Ep is 27.5 MV/m
- CM1 and CM2 are with HWR010
CM1: 23.5MV/m, assemble and test in 2016
CM2: 31MV/m, assemble and test in 2017, Improved assembly process and built local cleaning room for beam pipe connection in the tunnel.
- CM3 with Taper HWR015, New type for us
The first four HWR015(CM3-1 to CM3-4) leak 5 times in the clean room, So the are not good as the CM3-5



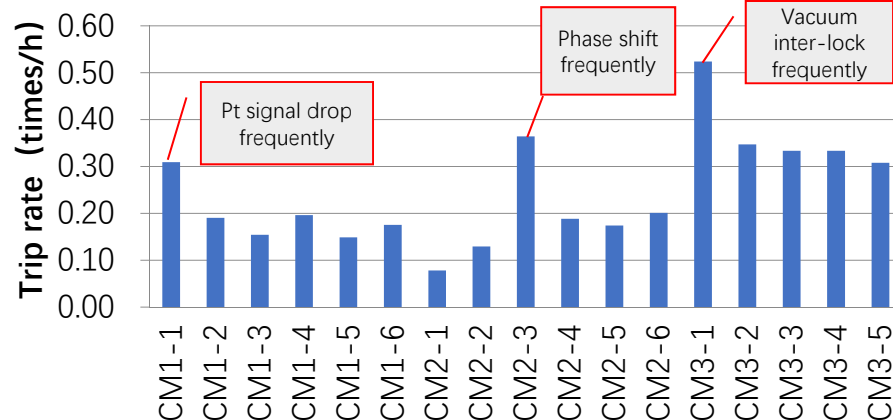
- Cavity test + beam test : 186 hours (close loop)
- Trips with phase vibrate, It 's the main phenomenon
- Trip by inter-lock decrease from cavity test to beam test
- Vacuum inter-lock decrease from 16% to 6% by improve the bias

Phase vibrate is phenomenon! Not reason! Maybe from: Microphonics, Tuner, Thermoacoustic oscillation, Helium pressure vibrate, LLRF?

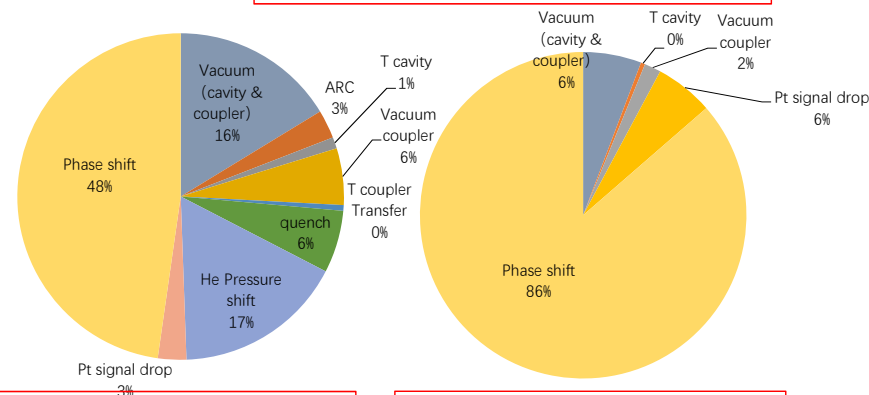
Main work of next stage



Trips during cavity test and beam test



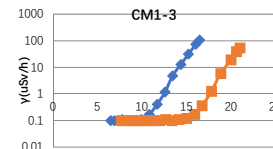
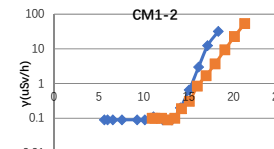
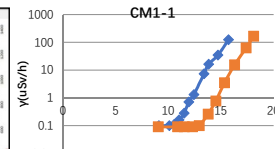
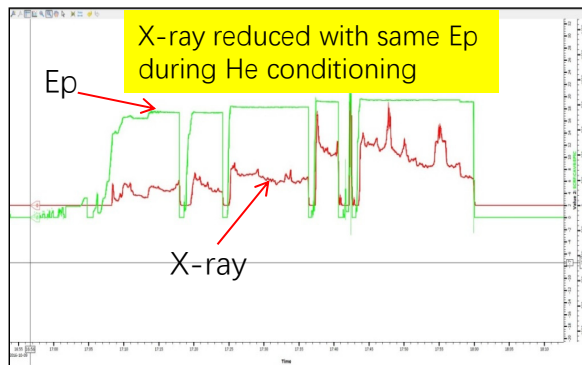
Trips during cavity + beam testing



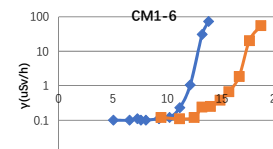
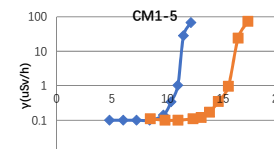
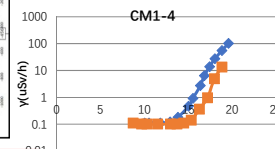
Trips during cavity testing

Trips during beam testing

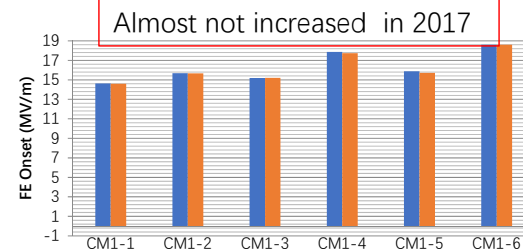
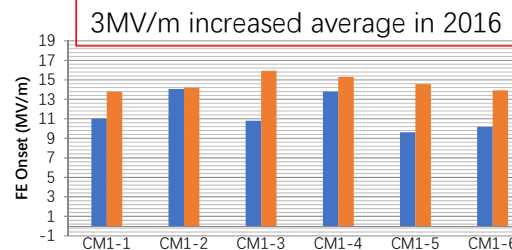
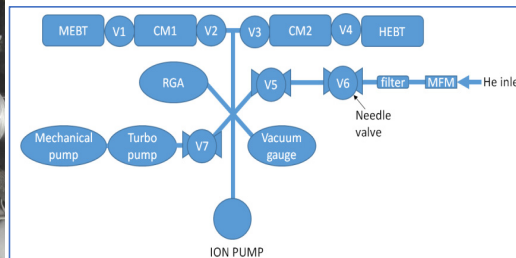
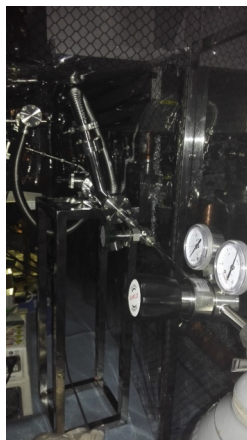
- Cavity performance test
- Supplying helium on the beamline
- RF conditioning with helium
- Bumping and warm up to 30K
- Cavity performance test



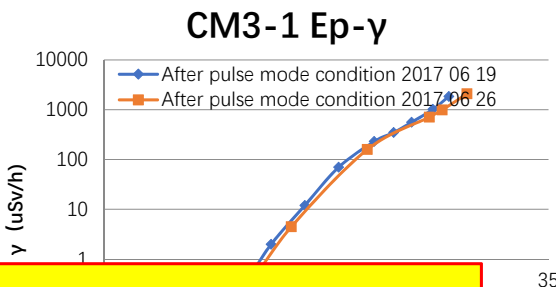
FE onset increased !



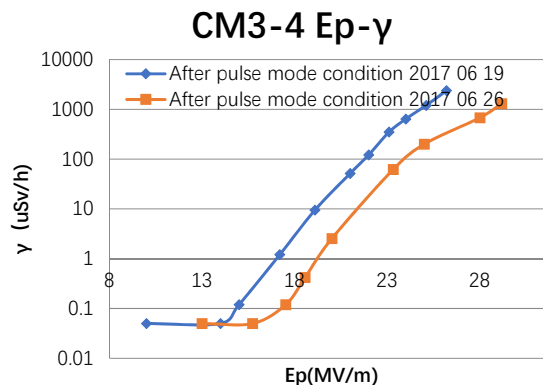
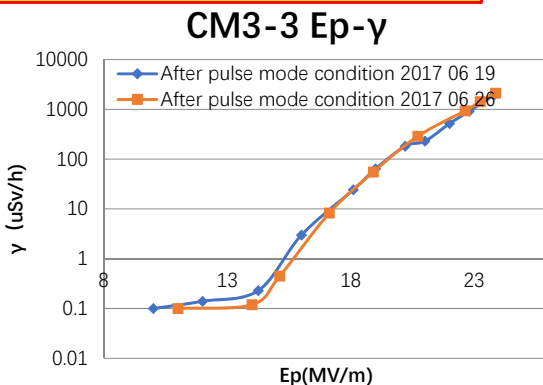
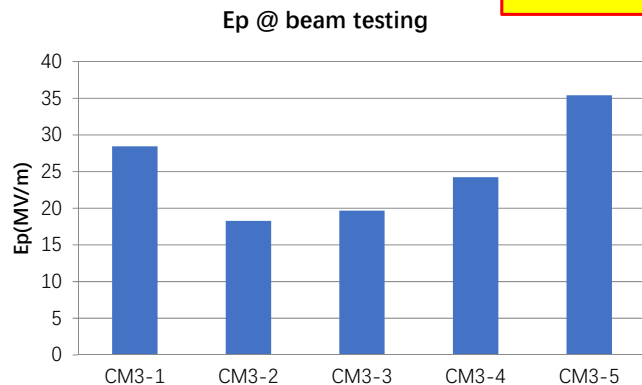
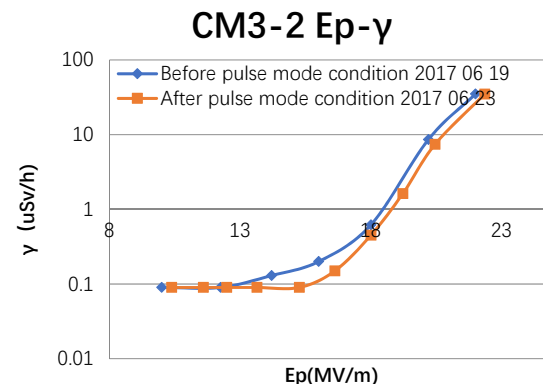
It's effective for performance recovery.



- Pulse mode RF on/off: 10ms/1s
- Power forward~3.8kW, $E_p \sim 35\text{MV/m}$
- Self excited mode
- Qext: 8.5E5
- Bandwidth: ~200Hz
- Fill-time: 1.6mS



RF pulse mode condition by this way is not very effective for reduce FE





Summary

- **The beam test confirm the HWR and Accessory equipment design, fabrication, procedure of processing, assembling and conditioning**
- **Research of the stability is the main work in the future—
Microphonics, Thermoacoustic oscillation, ponderomotive instabilities, Fast tuner.....?**
- **Mp free coupler research and development is another main work**
- **He processing is effective for performance recovery but not for performance further improve. Mechanism has to be study!**
- **Method of RF pulse mode condition we used is not very effective for reduce FE**



Thanks for the helps

LBL, J-Lab, TRIUMF, ANL, FNAL, MSU/FRIB, ORNL, SINAP,
IHEP, HIT, PKU, THU, RIKEN, CEA/Saclay, IPN/Orsay, IAP

Thanks for your attention