CRYOGENIC TEST RESULTS OF THE SPS PROTOTYPE RF-DIPOLE CRABBING CAVITY WITH HIGHER ORDER MODE COUPLERS *

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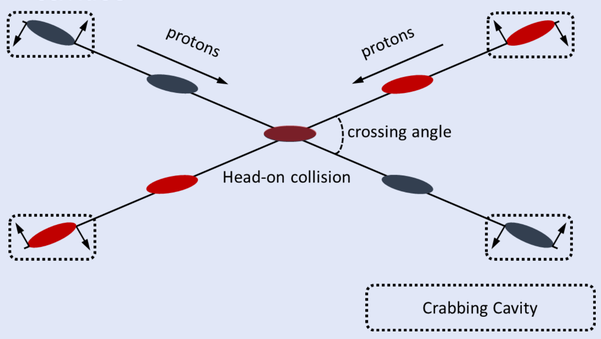
ABSTRACT

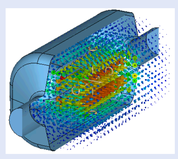
The rf-dipole crabbing cavity designed for the LHC High Luminosity Upgrade is designed to deliver a transverse kick of 3.34 MV; crabbing the proton beam in the horizontal plane. The proton beams of the LHC machine operating at 7 TeV each sets impedance thresholds on the crabbing cavity systems. The rf-dipole crabbing cavity is designed with a two higher order mode couplers to suppress those HOMs. The first prototype of the HOM couplers are fabricated at Jefferson Lab. This paper reports the cryogenic test results of the HOM couplers with the SPS prototype rf-dipole cavity.

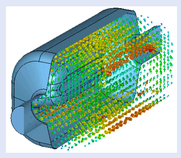
RF-DIPOLE PROTOTYPE CAVITY DESIGN

- Head-on collision of bunches with crabbing cavities



- RF-Dipole Cavity operates in TE_{11} like mode

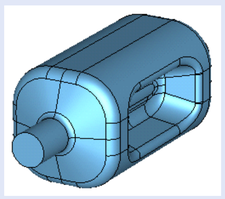

E Field

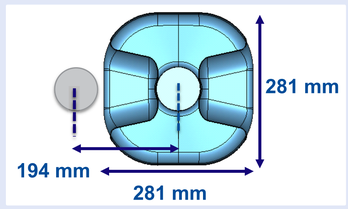

H Field

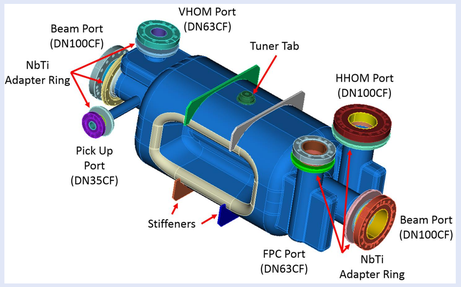
RF Properties		
Frequency	400.79	MHz
Aperture	84	mm
Nearest HOM	633.5	MHz
E_p^*	3.6	MV/m
B_p^*	6.2	mT
$[R/Q]_t$	429.7	Ω
Geometrical Factor (G)	106.7	Ω
R_tR_s	4.6×10^4	Ω^2
At E_t^* = 1.0 MV/m		
V_t	3.4	MV
E_p	33	MV/m
B_p	56	mT

Prototype Cavity

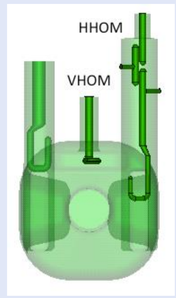
- 400 MHz square shaped cavity designed to fit in between the parallel beam pipes in LHC ring

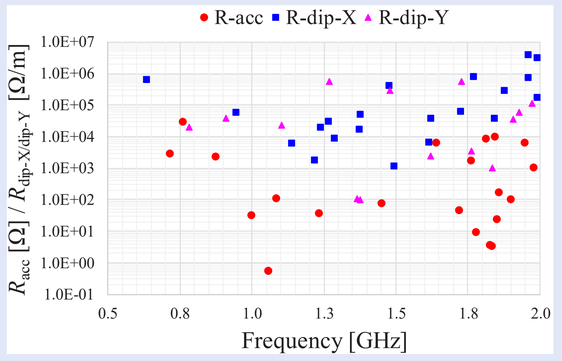


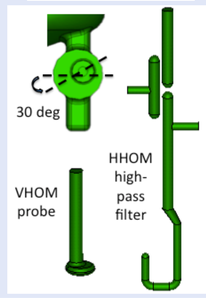




HOM Couplers of RF-Dipole Cavity





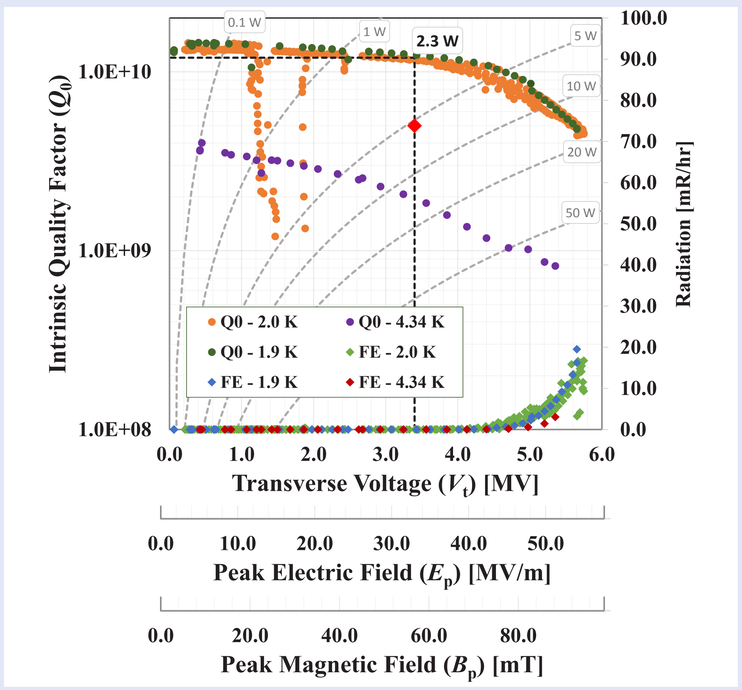


- RF-dipole cavity has only two HOM couplers: HHOM – High pass filter and VHOM coupler
- HOM couplers are designed to damp modes up to 2 GHz

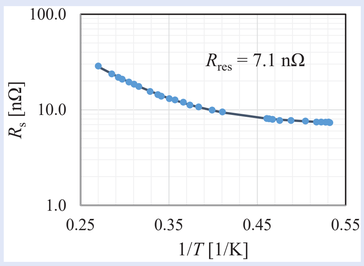
CRYOGENIC TEST RESULTS WITH HOM COUPLERS

RFD Bare Cavity Test Results

- Two prototype rf-dipole cavities were fabricated at Niowave Inc. and completed at Jefferson Lab under US LARP
- Test results of RFD-CAV-002 without HOM couplers

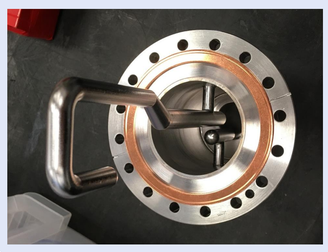


- Cavity achieved a maximum transverse kick (V_t) of 5.8 MV with peak surface fields of E_p=56 MV/m and B_p=96 mT
- At low fields Q_0 is greater than 1.3×10^{10}
- No field emission levels were observed below 4.5 MV
- Residual surface resistance is 7.1 nΩ

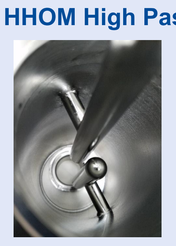


HOM Couplers

- Two sets of HOM couplers have been fabricated at Jefferson Lab
- HHOM filter processing: 25 micron BCP and no heat treatment

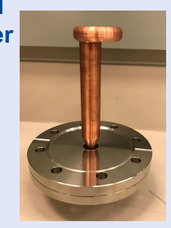


HHOM High Pass Filter



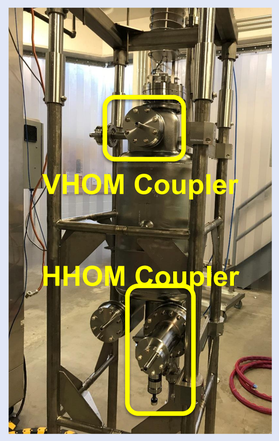
Probe

VHOM Coupler



Test Set Up

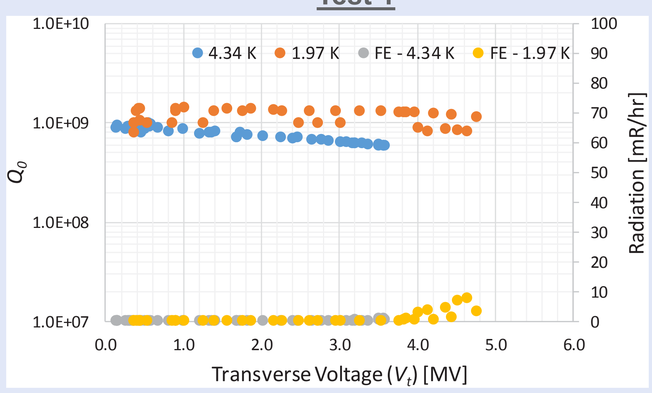
- RFD-CAV-002 assembly with mounted HHOM and VHOM couplers
- Measurements were carried out with at JLab
- To maintain consistency – same input probe, pick up probe and similar assembly configuration was followed as in the bare cavity rf test



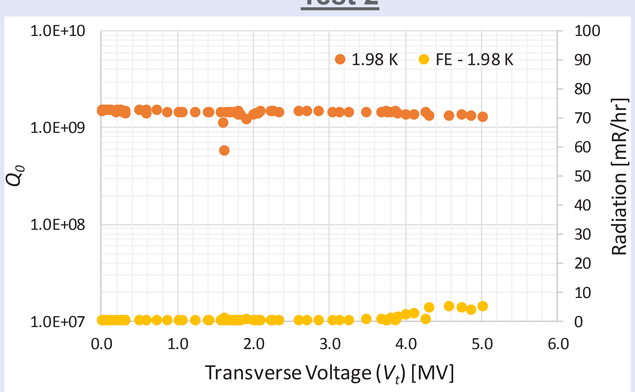
RFD Cavity Test Results with HOM Couplers

- Test 1 and Test 2 are with both HHOM and VHOM couplers
- Cavity was high pressure rinsed and low temperature baked at 120 C
- **Test 1**: with HOM couplers unterminated
- **Test 2**: with HOM couplers terminated

Test 1



Test 2

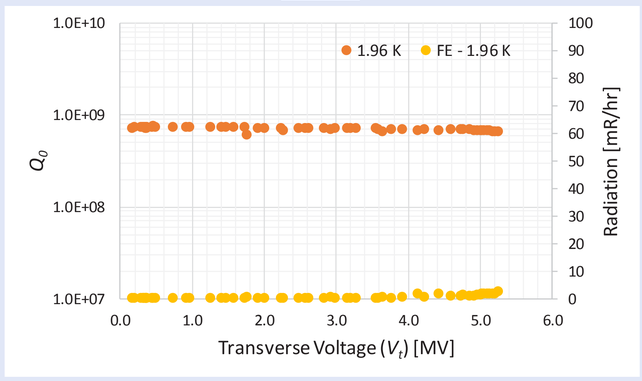


Test 1 and Test 2

- No new multipacting levels were observed
- Cavity didn't quench and was power limited
- Strong coupling of fundamental mode through VHOM coupler (Q_{ext} ~2×10^9)
- Cavity had a lower Q_0 compared to the bare cavity test
- Field emission was as low as in bare cavity test

Test 3

- Cavity was assembled with only HHOM coupler (no VHOM coupler) after high pressure rinse and followed a low temperature bake at 120 C
- Q_0 was lower than in Test 1 and 2
- Lower Q_0 was identified to be due to the losses at the Cu gasket
- Insertion of coupler generates currents leading to rf losses that reduces the cavity Q_0 to ~10^9



SUMMARY AND WORK PLAN

Cryogenic tests have been carried out on RFD-CAV-002 at Jefferson Lab with two HOM couplers, to validate the performance of the RFD cavity with HOM couplers. Initial tests (Test 1 and 2) were carried out with both HOM couplers and Test 3 was done only with HHOM coupler. The cavity achieved a transverse kick of 5 MV and didn't quench in any of the tests where the performance was limited by the rf power. No new multipacting levels or field emission levels were observed. The cavity Q_0 was lower than in the bare cavity test. It was found that the rf currents are creating additional losses at the Cu gasket and lowers Q_0 to about ~10^9.

Next cavity will be tested with only the HHOM coupler and with rf gaskets instead of the Cu gaskets. New RF gaskets are under fabrication.

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