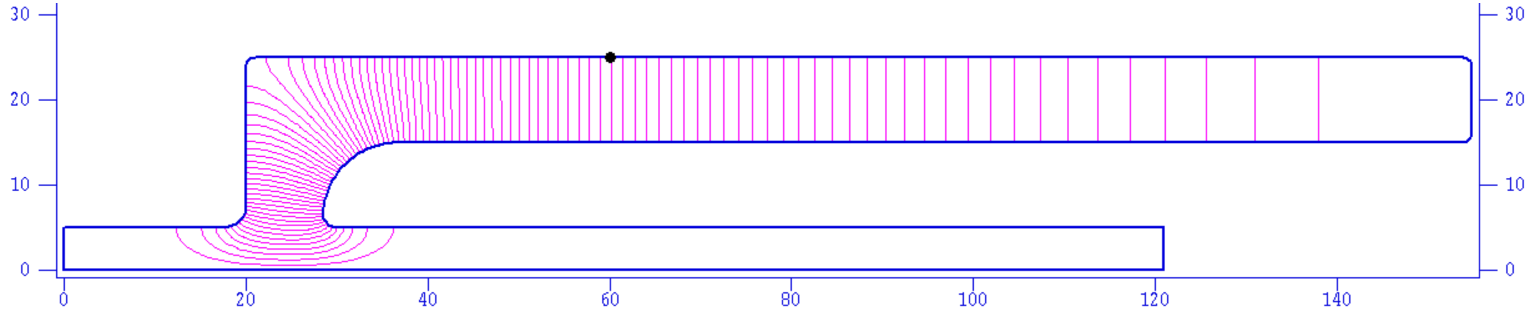
RHIC SRF Storage Cavity



Ilan Ben-Zvi

AIP Project Meeting

March 2008

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Charge - Thomas

Please organize a meeting during the week of March 24 on the status of the 56MHz SRF cavity project in preparation for starting it as an AIP project. Please present the status of the feasibility of the construction of the cavity, operation of the cavity in the RHIC ring and operation with high intensity beam. Also give a summary of the benefits of the cavity, address all issues that were brought up during the recent MAC review, and present the present status of the cost estimate.

MAC Concerns

- Fundamental damper might have to withstand very large power loads depending on the ramp scenario, and detailed heating simulations are needed – Eunmi Choi
- The mechanical movements of this damper several times a day - tests for reliability and life time should be performed once a cold and vacuum tight setup has been completed – Daniel Chenet

MAC Concerns

- A monopole mode was identified at 1100 MHz with unexpectedly large R/Q of approximately 30 Ohms. Stability analysis has yet to be done for this mode – Mike Blaskiewicz
- So far instabilities due to individual cavity modes were considered. The effect of overlapping modes should also be considered – Mike Blaskiewicz

MAC Concerns

- Multipacting simulations show the potential for problems, which may lead to changes in geometry – Damayanti Naik

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Status

- Cavity shape and characteristics known
- Stability analysis mostly done
- Dampers electrical design done
- Mechanical design under way
  - Need refinement of mechanical stability
  - Need refinement of thermal design
  - Solution for pressure vessel code
- Chemistry and Vertical Testing moving forward

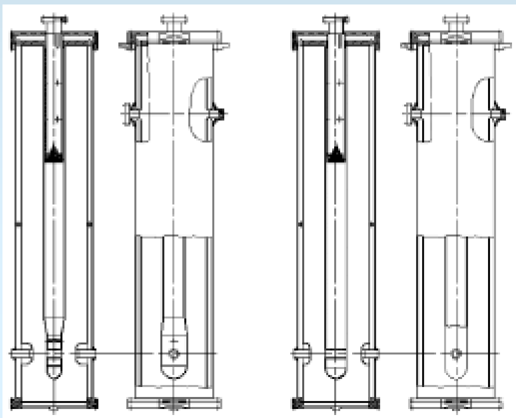
Status (continued)

- Slow tuner design done
- Fast tuning - solved
- 1st prototype constructed, couplers are in the shop (2nd prototype will be needed)
- Multipacting 2-D advanced stage, 3-D to start soon.
- Cryogenic design under way
- Cost and schedule estimate made.

Feasibility-construction of cavity

- 80 MHz SRF quarter wave resonators in operation in various laboratories, notably LNL and MSU.
- ATLAS uses six 48.5 QWRs
- 57 MHz SRF RFQ built and tested at Stony Brook (much more complex structure)

Present QWR performance example: LNL bulk Nb, 80 MHz double wall

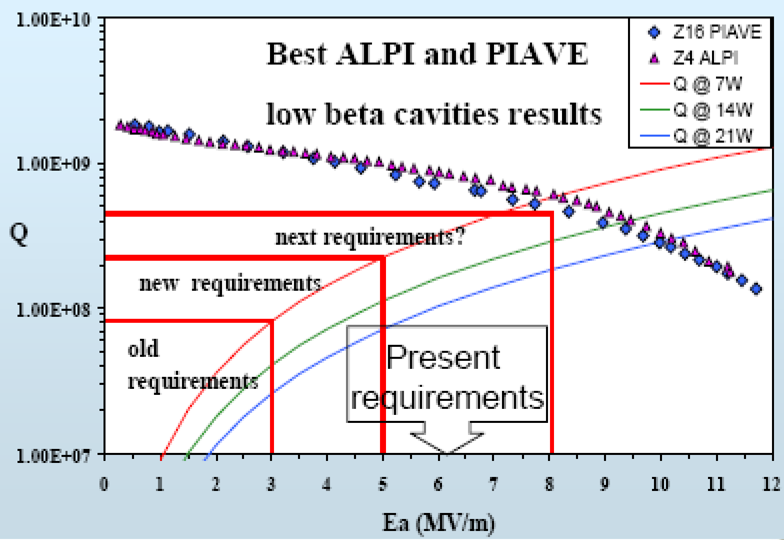


PIAVEβ=0.047 and ALPI β=0.055

Maximum fields:
- E_a=11.7 MV/m
- E_p= 57 MV/m
- B_p=120 mT

LNL 80 MHz, β=0.055 cryostat

LNL PIAVE 80 MHz, β =0.047 QWR



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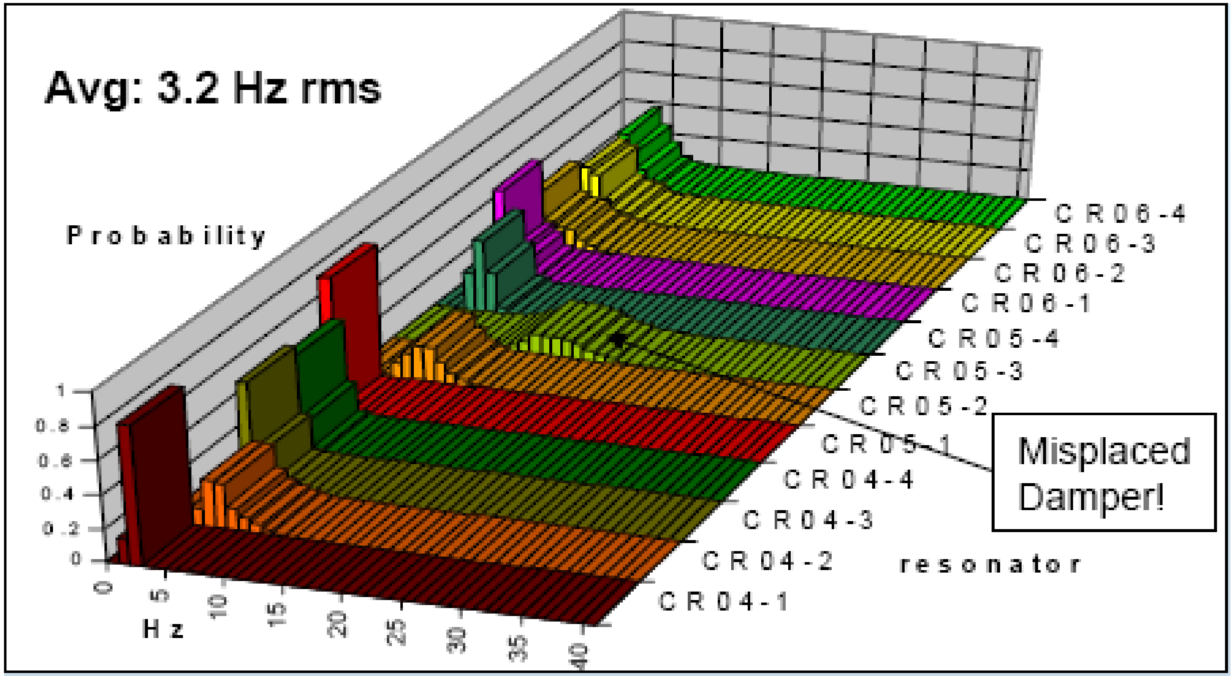
Required for RHIC QWR

At 2 MV/m: 858 Gauss and 34.8 MV/m peak surface fields

At 2.5 MV/m: 1073Gauss and 43.5 MV/m peak surface fields

Frequency stability, Legnaro 80 MHz QWR



Distributions of the frequency oscillation amplitudes in a 24 hour record for all low beta cavities in ALPI.

Stability requirements in RHIC

- In RHIC one requires amplitude noise at twice the synchrotron frequency (~240 Hz) to be 85 dB in 5 Hz bellow the carrier.
- Given a resonator detuning of about 100 to 200 Hz, this requires a stability of about 0.005 Hz in the 5 Hz band around the synchrotron frequency.
- Assuming a mechanical Q of 50 for the cold Legnaro resonator, the noise at the synchrotron frequency is expected to be under 0.03 Hz rms

Stability (continued)

- It is reasonable to expect that we can do better than Legnaro (lower noise level), given our ability to isolate the helium system from the refrigerator as well as mechanical design for lower sensitivity.
- The 1 kW RF amplifier can provide amplitude control equivalent to $\pm$1.5 Hz tuning by introducing reactive power.
- This should provide more than adequate amplitude stability.

Backup

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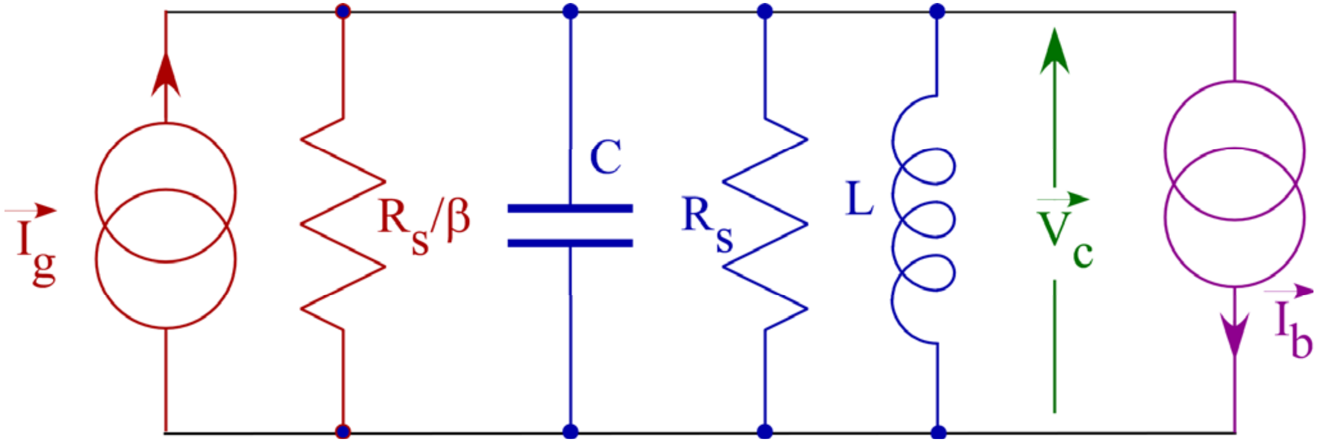

$$Y_L = \frac{\vec{I}_T}{\vec{V}_c} = \frac{1+\beta}{R_L} + j\left(\omega C - \frac{1}{\omega L}\right)$$

$$I_g = \frac{2V_{FWD}}{n Z_0} = \sqrt{\frac{8\beta P_{FWD}}{R_s}}$$

$$I_b \approx \frac{2q}{T_b}; \quad \phi_b = \phi_s$$

$$\vec{I}_g - \vec{I}_b = V_c \left[\frac{\beta + 1}{R_s} + j \frac{\delta}{R/Q} \right]$$

$$\delta = 2 \frac{\Delta f_{\mathrm{det}}}{f}$$

$$\frac{\Delta f_{vib}}{\Delta f_{\mathrm{det}}} = \frac{\mathrm{Im}\left(\vec{I}_g\right)}{I_b}$$

$$I \equiv \mathrm{Im}\left(\vec{I}_g\right)$$

$$I^2 = \frac{8\beta P_{FWD}}{R_s} - V_c{}^2 \frac{(\beta+1)^2}{R_s{}^2}$$

$$\beta_{opt} = 2\frac{P_{FWD}}{P_0} - 1 = 49$$

$$I^2 = \frac{400 P_{FWD}}{R_s} - \frac{5000 P_0}{R_s}$$

$$R_s = \frac{V_c{}^2}{2P_0} = 0.8\times 10^{11}$$

$$I = 1.6\times 10^{-3}$$

$$\Delta f_{vib} \approx \pm 1.5\,\mathrm{Hz}$$