International Workshop on Higher-Order-Mode Damping in Superconducting RF Cavities

701 Clark Hall, Cornell University, October 11 -13, 2010

Agenda

Monday, October 11, 2010

9:00 – 9:15: Welcome (M. Liepe)

9:15 – 11:00: *HOM damping requirements for various projects*

Session chair: I. Ben-Zvi

Task: Collect key HOM specs for different projects.

- **HOM damping requirements for SRF deflecting cavities** (A. Nassiri, 15 min)
- **Higher order mode damping considerations for the SPL cavities at CERN** (W. Weingarten, 15 min)
- **HOMs in the Project X linac** (V. Yakovlev, 15 min)
- **HOM damping requirements for various projects** (all, 30 min total)
  - Bunch length, bunch charge, beam current, number of cavities
  - Cavity frequency, number of cells, longitudinal loss factor at design bunch length
  - Single bunch HOM power spectrum
  - Average HOM power per cavity ($k*Q_b*I$)
  - Worst case peak HOM power per cavity in case of resonant excitation of modes
  - Required damping (typical Q-values only!) of monopole, dipole, and quadrupole modes
- **Discussion: HOM damping requirements** (all, 30 min total)

11:00 – 11:30: *Introduction to HOM damping*

Session chair: I. Ben-Zvi

- **A comparison of the HOM damping efficiency for various SRF coupler schemes** (F. Marhauser, 30 min)

11:30 – 1:00 PM: *Working lunch*

1:00 – 5:00 PM: *Antenna/ loop HOM couplers*

Session chair: J. Knobloch

- **HOM Damper and Filter Design for 56MHz SRF Cavity for RHIC** (Qiong Wu, 20 min)
- **HOM Damping Properties of Fundamental Power Couplers in the Superconducting Electron Gun of the Energy Recovery LINAC at Brookhaven National Laboratory** (L. Hammons, 20 min)
- **Capacitive-Antennae HOM Damper** (H. Hahn, 20 min)
- **New HOM coupler design for High Current Superconducting cavity** (W. Xu, 20 min)
- **Experience with 3.9 GHz loop couplers** (T. Khabiboulline, 20 min)
- **Heating in DESY style HOM couplers in cw operation** (J. Sekutowicz, 20 min)
- **Heating of HOM loop couplers in CW mode** (W.Anders/A.Neumann, 20 min)
- **HOM damping variations in SRF cavities** (F. Marhauser, 20 min)
- **Optimization of HOM Couplers using Different Time Domain Schemes** (C. Potratz, 20 min)
- **Computation of Coupler Damping Properties in Concatenated Arrangements** (H.-W. Glock, 20 min)
- **Discussion: antenna based HOM damping** (all, 40 min)
  - Effective HOM damping frequency range
    - Coupling to high frequency modes?
  - Measured and/or simulated HOM Q-values for given cavity design vs. frequency (no BBU simulation results!)
    - Coupling to monopole, dipole, and quadrupole modes
    - How many antenna/loop couplers are required per cavity to guarantee effective damping for all polarization angles?
    - Design and results from DESY, TJNAF, BNL
  - Maximum HOM power handling and extraction
    - Estimate of the heat load to ~2K and all other intercept temperatures at full HOM power
  - Coupling to the fundamental mode and suppression
    - Thermal limitations, e.g. long pulse vertical test (DESY), cw-version for the CEBAF upgrade cavities
    - High thermal conduction feedthroughs
    - Niobium or Cu antenna? Impact on cost?
    - Filter design and tuning, especially with large number of couplers per cavity. Reliability/ success rate?
    - Filter always needed?
  - Cleanness challenges and solutions
    - Field emission
    - Trap sulfur during EP?
  - Extra beamline length required per cavity (compared to linac without HOM damping)
  - Mechanical / fabrication challenges and solutions
    - FNAL experience at 3.9 GHz and SNS experience
    - Multipacting
    - Mechanical failure
  - Cost vs. design and material choices
    - Niobium vs. normal conducting
    - Filter design and complexity
    - Cabling; load inside our outside of vacuum vessel?
  - Other challenges, limitations and solutions

Tuesday, October 12, 2010

9:00 – 10:00 AM: *Waveguide HOM damping*

Session chair: S. Belomestnykh

- **Waveguide HOM damping studies at JLAB** (R. Rimmer, 30 min)
- **Discussion: waveguide HOM damping** (all, 30 min)
  - Effective HOM damping frequency range
    - Coupling to high frequency modes?
  - Measured and/or simulated HOM Q-values for given cavity design vs. frequency (no BBU simulation results!)
    - TJNAF designs and results
  - Maximum HOM power handling and extraction
    - Estimate of the heat load to ~2K and all other intercept temperatures at full HOM power
  - Coupling to the fundamental mode and suppression
  - Cleanness challenges and solutions
    - Cleaning of waveguide sections
  - Extra beamline length required per cavity (compared to linac without HOM damping)
  - Mechanical / fabrication challenges and solutions
  - Cost vs. design and material choices
    - Superconducting or normal conducting waveguide sections?
    - Number of waveguides per cavity required
    - Length of waveguide section
    - Absorber inside or outside of vacuum vessel?
    - Water cooling vs. cryogens; risks involved
    - Temperature of loads at end of waveguides
    - Shielding of IR radiation from warm load
    - Water cooling and mechanical cavity vibrations
  - Other challenges, limitations and solutions

10:00 – 12:00 PM: *RF absorbing materials*

Session chair: M. Liepe

- **RF absorber studies at Cornell, part 1** (V. Shemelin, 20 min)
- **RF absorber studies at Cornell, including DC conductivity, part 2** (E. Chojnacki, 20 min)
- **RF absorber studies at KEK** (M. Sawamura, 20 min)
- **Measurements of absorber materials from room temperature to 2K** (F. Marhauser, 20 min)
- **Discussion: HOM absorbing materials** (all, 40 min)
  - Room temperature and cryogenic material complex mu & eps (temperature dependence of absorption) of various dissipative materials vs. frequency (ferrites, ceramic with carbon, CNT…)
  - DC conductivity of dissipative materials and its temperature dependence
  - Mechanical and thermal properties of dissipative materials
  - Vacuum properties of dissipative materials
  - Coatings and other methods to avid electrostatic charging of dissipative materials
  - Fabrication of dissipative materials and reliability of achieving specs
  - Fabrication cost of different dissipative materials

12:00 – 1:30 PM: *Working lunch*

1:30 – 5:30 PM: *Beamline HOM loads*

Session chair: M. Liepe

- **Ferrite HOM Load Surrounding a Ceramic Break** (L. Hammons, 20 min)
- **Absorbing materials for beamline absorbers: How good is good enough?** (Nick Valles, 20 min)
- **Experience with the Cornell ERL beamline absorber prototype and future plans** (E. Chojnacki, 30 min)
- **Resonant HOM load made of a resistive material** (V. Shemelin, 20 min)
- **Test of the Beam Line Absorber at FLASH** (J. Sekutowicz, 20 min)
- **Cooling test of HOM absorber model for cERL in Japan** (M. Sawamura, 30 min)
- **Operation Experience of HOM absorbers at KEKB** (T. Furuya, 20 min)
- **Beamline absorber work at Muon Inc** (R. Johnson, 20 min)
- **Design and Application of the High-Efficiency HOM Absorbers at PEP-II** (A. Novokhatski, 20 min)
- **Discussion: beamline absorbers** (all, 40 min)
    - Effective HOM damping frequency range
    - Measured and/or simulated HOM Q-values for given cavity design vs. frequency (no BBU simulation results!)
        - Cornell, DESY, BNL, KEK designs
    - Maximum HOM power handling and extraction
        - What is the optimal operating temperature?
        - Heat transfer and thermal connections
        - Estimate of the heat load to ~2K and all other intercept temperatures at full HOM power
    - Coupling to the fundamental mode and suppression
    - Cleanness challenges and solutions
        - Cleaning of absorber materials
        - Risk of particle generation?
        - How to quantify the absence or presence of RF absorber material particulate generation that could spoil the Q of nearby SRF cavities?
        - Coatings?
    - Extra beamline length required per cavity (compared to linac without HOM damping)
    - Mechanical / fabrication challenges and solutions
        - Are bellow sections between cavities needed / desirable?
        - Heat intercept and static heat loads to cavities
        - Brazing, soldering, metallization of ceramics/ferrites to heat sinks.
        - Absorber tiles vs. rings
        - Accurate mechanical modeling that includes plastic deformation of material.
    - Cost vs. design and material choices
        - Thermal matching of heat sinks to ceramic/ferrites
        - Copper coating of beam pipe sections or stainless steel?
    - Other challenges, limitations and solutions

Wednesday, October 13, 2010

9:00 – 10:15 AM: *RF simulation tools (2D, 3D)*

Session chair: E. Chojnacki

- **ACE3P and HOM power flow in the Cornell ERL** (Liling Xiao, 20 min)
- **HOM simulations with ANSYS** (S. Posen, 20 min)
- **Higher Order Mode Heating Analysis for the ILC Superconducting Linacs** (C.r Nantista, 20 min)
- **Discussion: HOM simulations** (all, 15 min)
  - Which problems need 3D models?
  - Which problems require only 2D?
  - Which 3D software allows complex mu & eps?
  - Which 3D software is up to the job?
  - Which 2D software allows complex mu & eps?
  - Which 2D software is up to the job?
  - FEM vs. FD codes
  - How high in frequency can/should one go?
  - How much can one trust the simulations? What safety factor should be included? Comparison of simulations and measurements.
  - Time domain vs. frequency domain
  - Choice of boundary conditions at cavity beam tube ends (open, electric, magnetic). What is realistic for a large linac installation?

10:15 – 11:30 AM*:* *Measurement Methods (HOMs, material properties)*

Session chair: E. Chojnacki

- **RF absorber studies using waveguides in transmission** (V. Shemelin, 20 min)
- **HOM-BPMs at the 3.9 GHz Superconducting Cavities for FLASH and the European XFEL** (R.M. Jones, 20 min)
- **Experiments on HOM Spectrum Manipulation in a ILC 1.3 GHz Cavity** (T. Khabiboulline, 20 min)
- **Discussion: HOM measurements** (all, 15 min)
  - Measurement *methods* of RF absorbing materials (complex mu & eps, mechanical properties…)
    - Cornell waveguide method, terminated waveguide (TJNAF), resonator methods, …which method gives reliable data at operating temperatures?
    - DC conductivity, mechanical and thermal methods
  - Measurements in cavities and cavity prototypes (copper)
    - How much can one trust HOM measurements on individual cavities?
    - Boundary conditions at beam tubes?
    - Are cold measurements needed?
    - Are beam measurements needed?
    - Are copper modes needed?

11:30 – 1:00 PM*:* *Closeout*

- Summary of HOM damping schemes currently available and *fully* developed, including parameter specs (frequency range, power handling capabilities...)
- Summary of future, potential performance of improved versions, including outstanding challenges/problems, potential solutions, and R&D
- Volunteers to perform the R&D, the time frame, and report the results