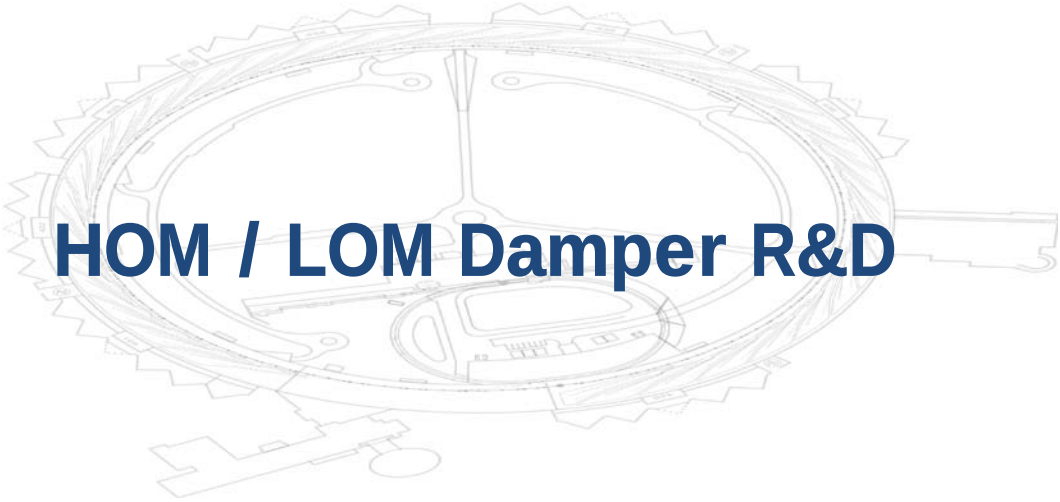


# HOM / LOM Damper R&D

Geoff Waldschmidt

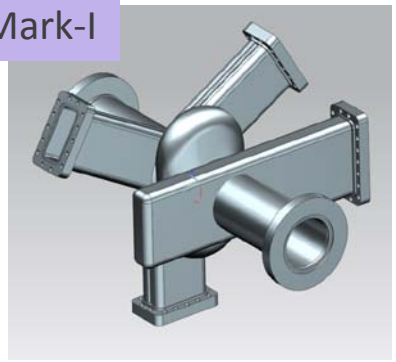
SPX Workshop
July 18, 2011

# Outline

- SPX cavity impedance and damper loading
- HOM damper assembly
- LOM damper
- LOM RF window design
- Test Plan
- Summary

# SPX Cavity Impedance*

Mark-I

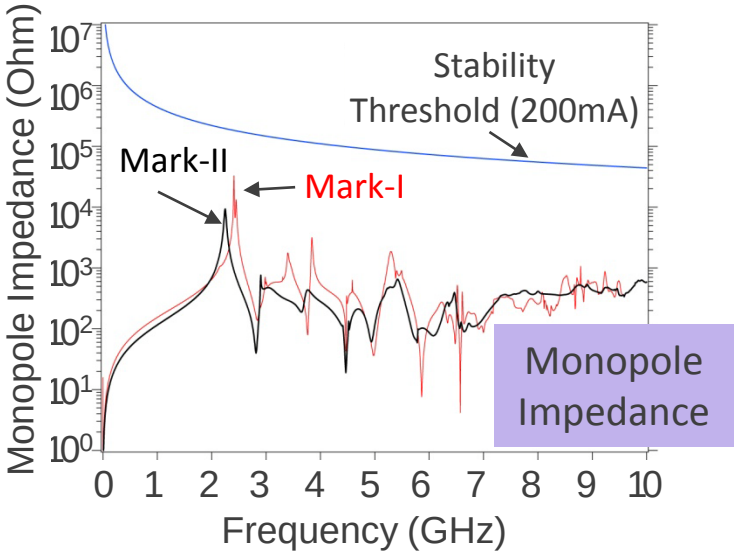


Mark-II

Longitudinal $R_s * f_p < 0.44 M\Omega - GHz$

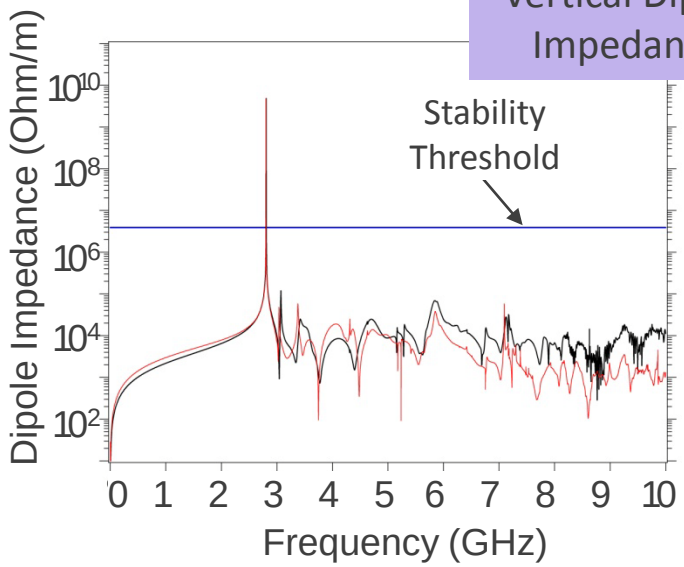
Horizontal dipole $R_t < 1.3 M\Omega / m$

Vertical dipole $R_t < 3.9 M\Omega / m$

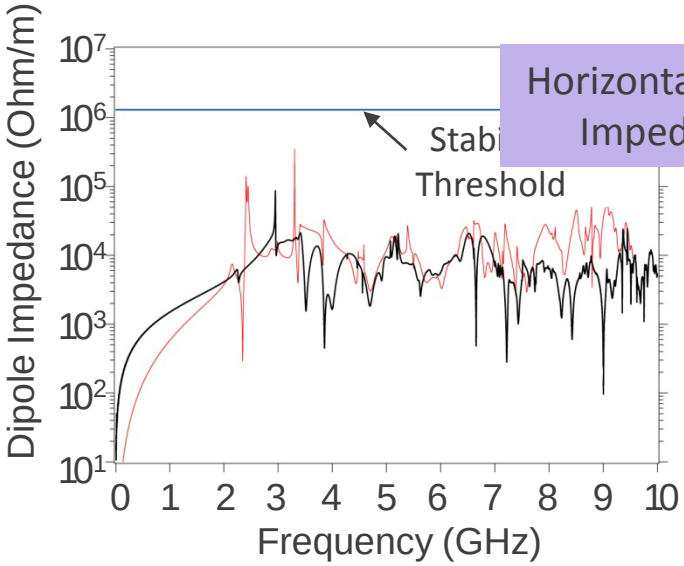



Monopole Impedance

Vertical Dipole Impedance



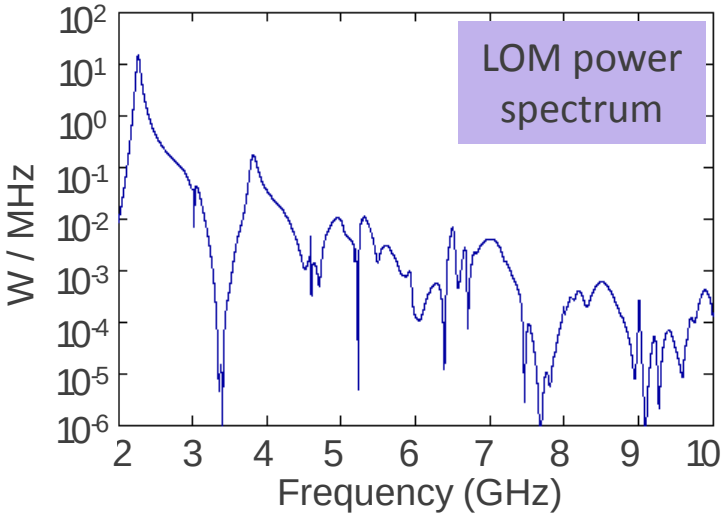

Horizontal Dipole Impedance



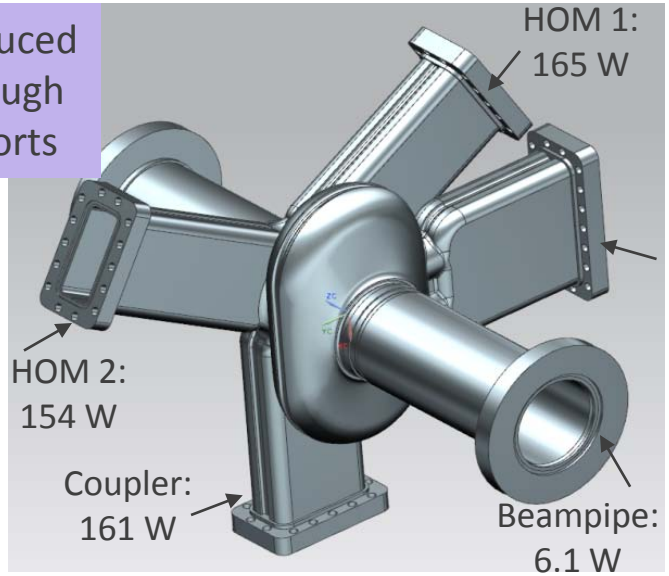

*Courtesy: H. Wang

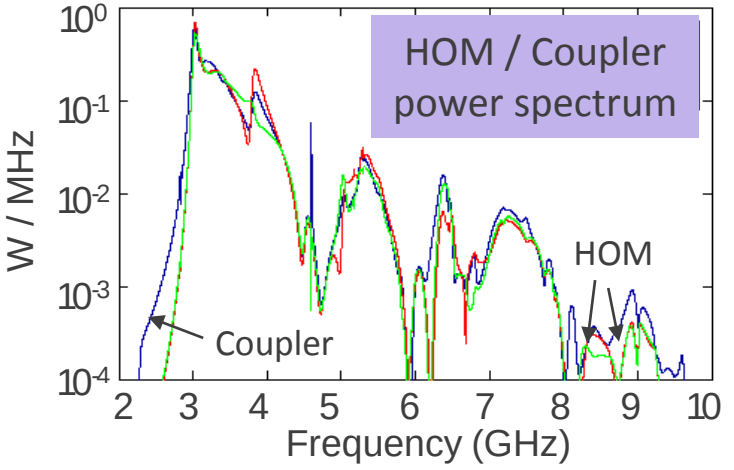
# HOM Induced Power

- Total LOM/HOM induced power is 1.8 kW for the Mark-II cavity.
- Design specifications for dampers: LOM = 2 kW / HOM = 0.3 kW
- LOM damper is especially challenging due to high-power , high frequency, and relatively narrowband, spectrum at 2.3 GHz.



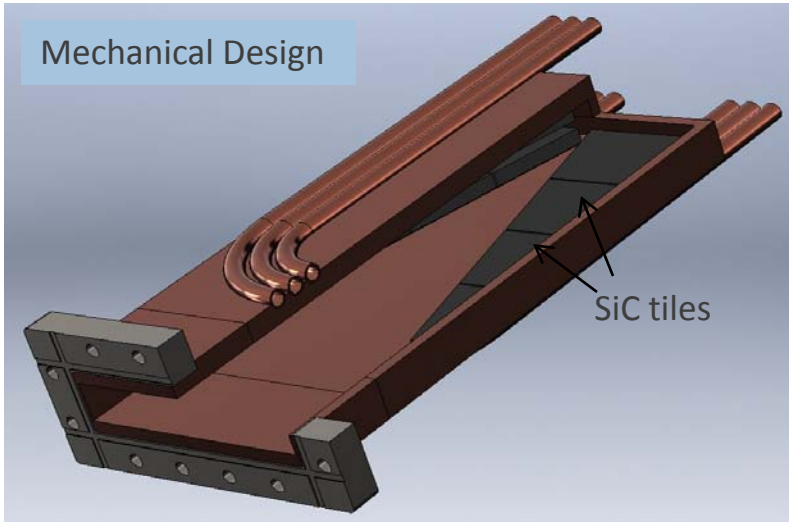

HOM induced loss through cavity ports

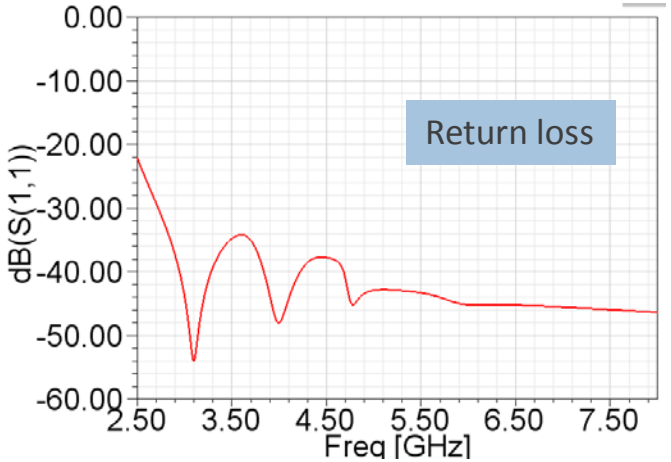


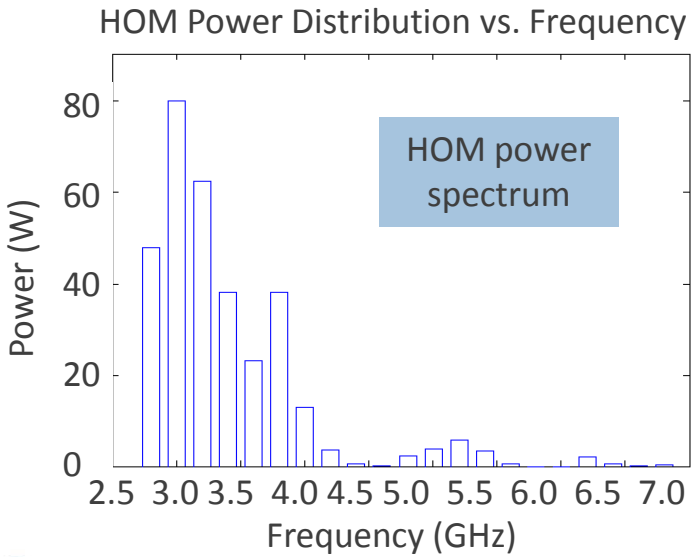

Power spectral density at cavity ports

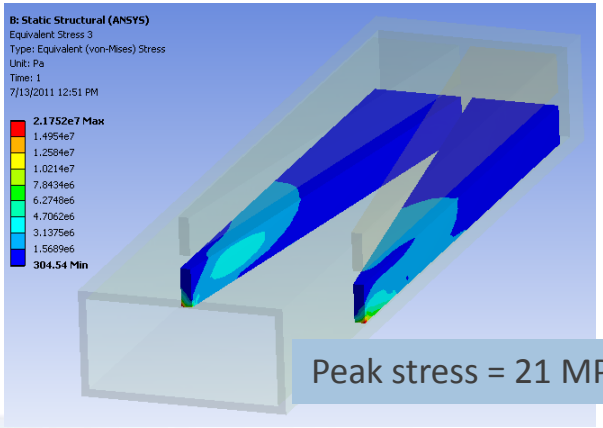
# HOM Damper



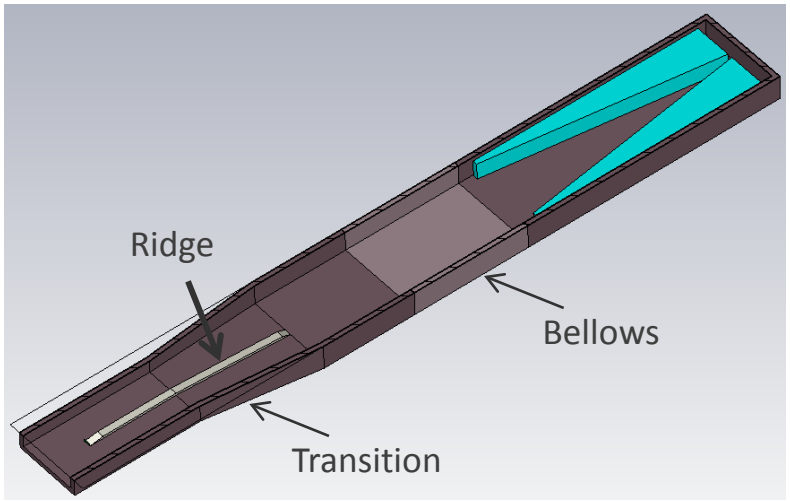

- Waveguide damper design is based on PEP-II (10 kW) and KEK (500 W) dampers.
- HOM damper load is in-vacuum and must be broadband beyond 8 GHz.
- SiC material has high thermal conductivity, lossy rf properties, and vacuum compatibility.

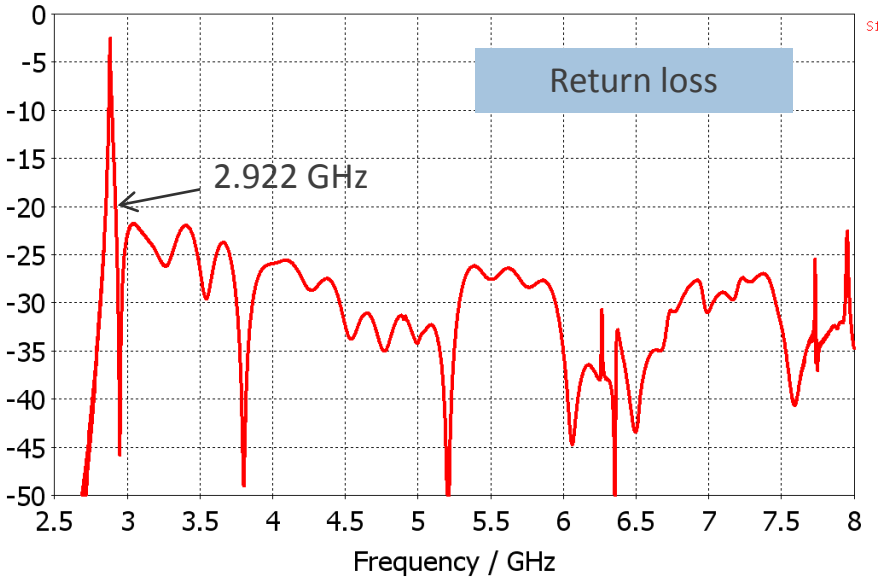


# HOM Damper Assembly

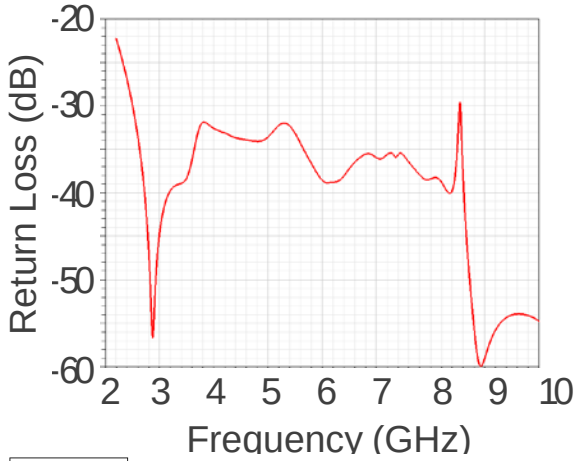
- HOM assembly will be located in the insulating vacuum of the cryomodule and must be compact.
- Tapered ridge was designed to increase the electrical length of the transition for the lower-frequency HOMs.
  - Reduces overall length of transition.
  - HOM frequencies range from 2.92 GHz where the waveguide cutoff frequency is 2.88 GHz
- WR284 rectangular bellows is expected to be integrated into design for vibration isolation and thermal transition.

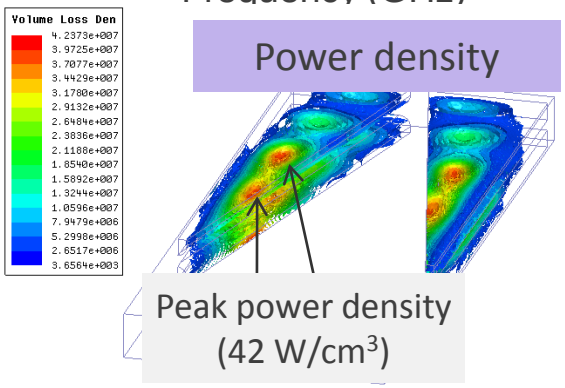


# LOM Damper Design: In-Vacuum

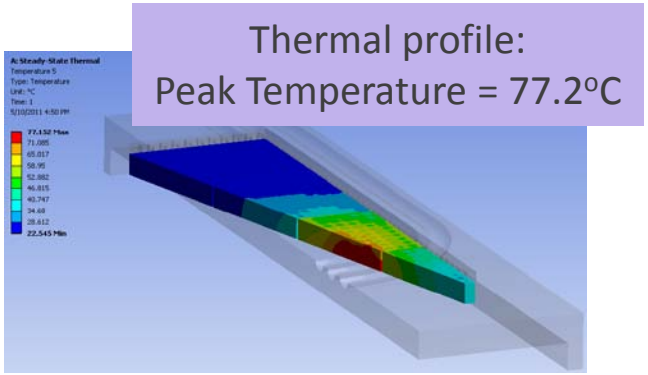
- Four-wedge design alleviates stresses produced by the high-power (2 kW), high-frequency (2.3 GHz) monochromatic LOM load.
  - Distributes rf load over damper volume
  - Reduces thermal gradient across damper
  - Reduces and symmetrizes deformation
- Temperature gradient (°C/mm) is comparable to the PEP-II waveguide dampers.
- Bulk operational stresses are ~ 50 MPa which is below the documented tensile strength of sintered SiC (200 - 450 MPa)




Comparison: PEP-II and SPX

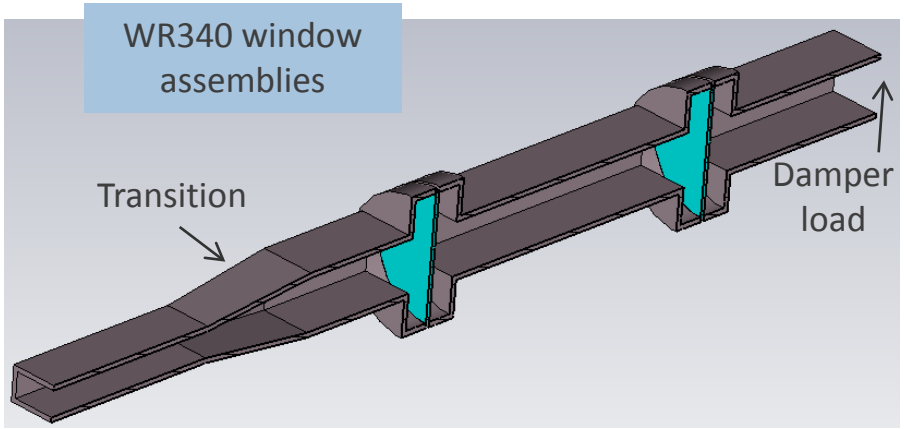
| | Power (kW) | Peak Density (W / cm³) | Peak Gradient (°C / mm) |
|---|---|---|---|
| PEP-II* | 10 | 18.5 | 3.2 |
| SPX | 2 | 42.4 | 4.9 |

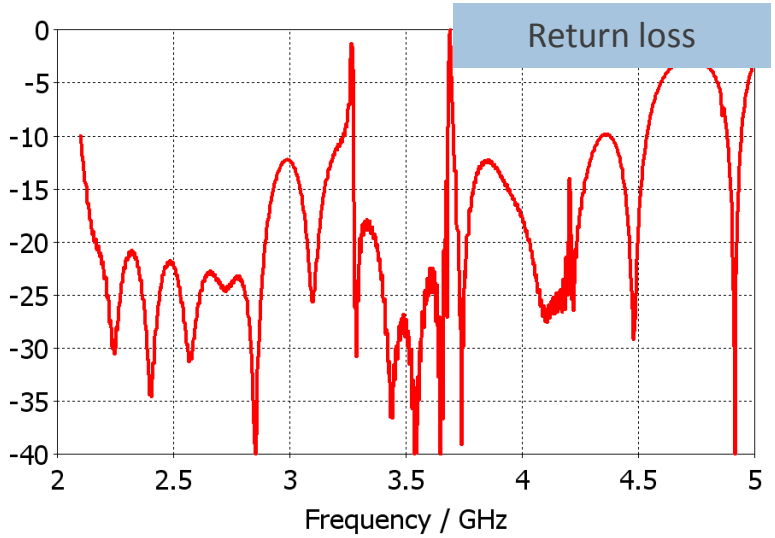



* Courtesy: B. Rimmer

# LOM Broadband Double Window Assembly

- In-vacuum LOM damper design (previously described) is being pursued as an alternate option.
- LOM broadband double window is planned for the baseline design in order to bring the LOM load out of the cryomodule.
- LOM is primarily narrowband between 2.2-2.5 GHz (Mark-I and Mark-II cavities)
- Dampers are WR340 loads and will operate out-of-vacuum.
- Frequency response of double window / damper assembly must be sufficiently broadband so that new resonances do not drive beam instability.

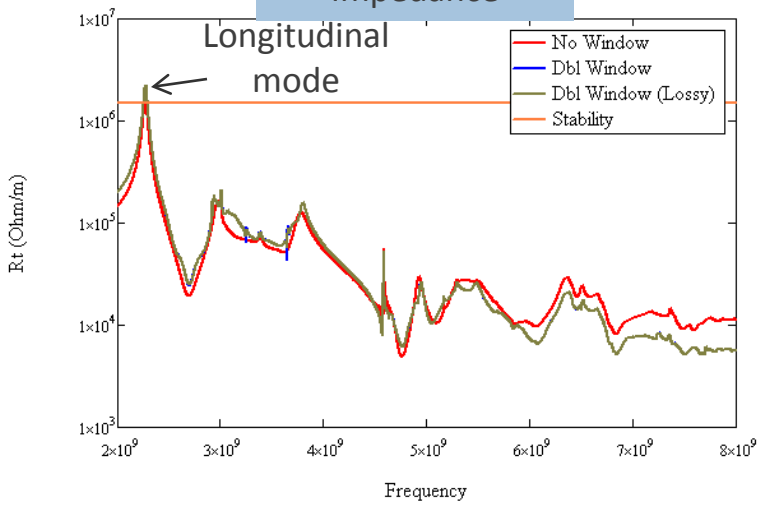


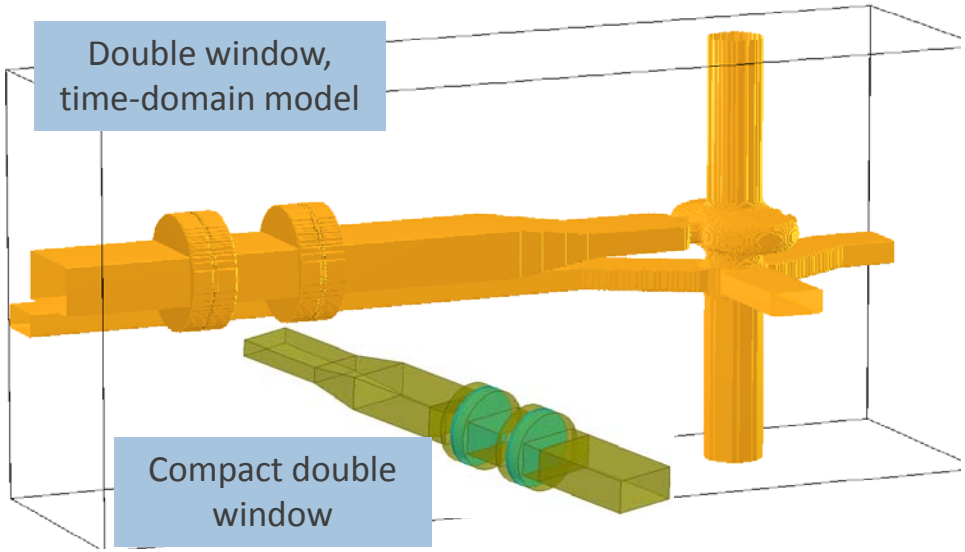
# LOM Window: Impedance

- Simulated broadband impedance spectrum does not show additional cavity resonances.
- Cavity impedance is not strongly affected by windows based on simulations.
- Compact double window, as shown, was analyzed – actual geometry to be simulated.

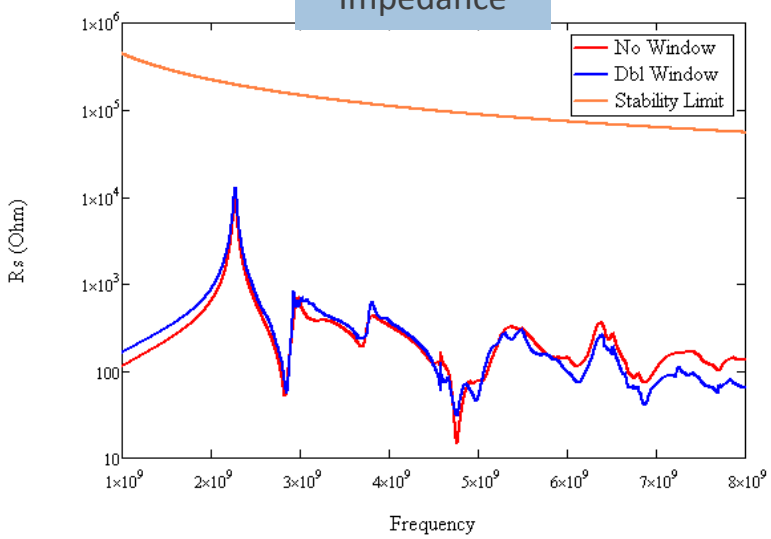
Horizontal Dipole Impedance




Double window, time-domain model



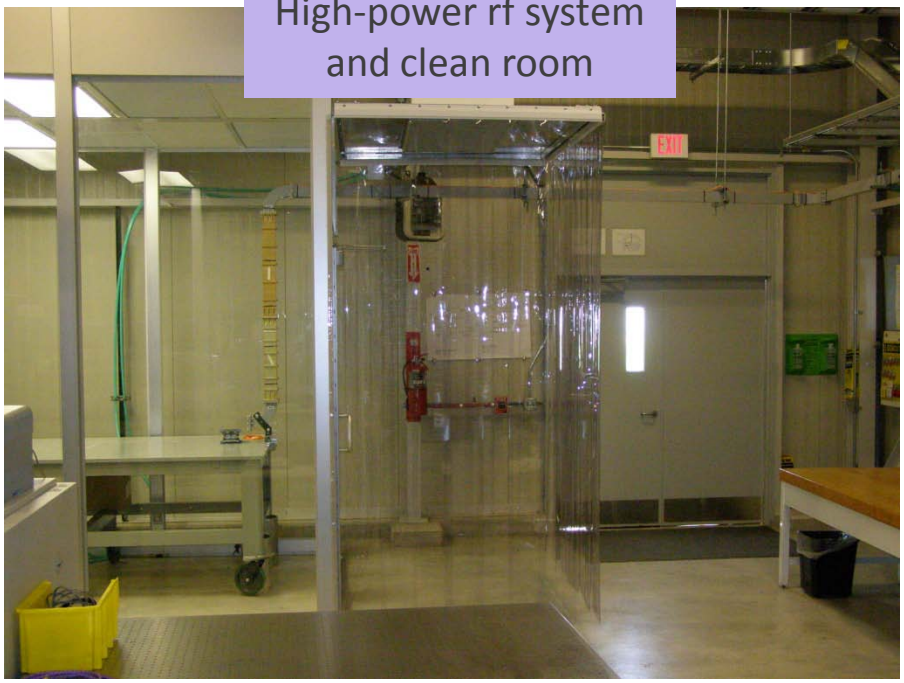

Longitudinal Impedance



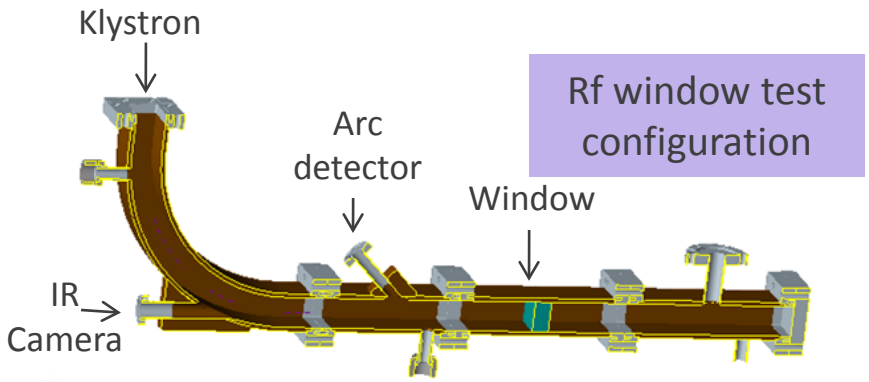
# Development Plan

- R&D effort for the brazing of SiC tiles to copper substrate is ongoing. (Preliminary results will be discussed by Bran.)
- Particulate and vacuum tests of damping material is planned.
- A cyclic test of braze joint between dampers and copper will be performed.
- Extensive low-power and high-power rf tests of damper assembly will be performed.
- Al cavity prototype will be tested with damper assemblies

Klystron and Power Supply



High-power rf system and clean room



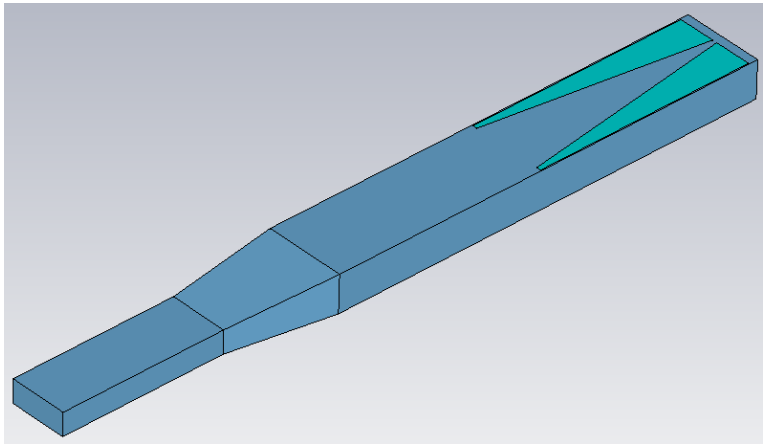

Rf window test configuration

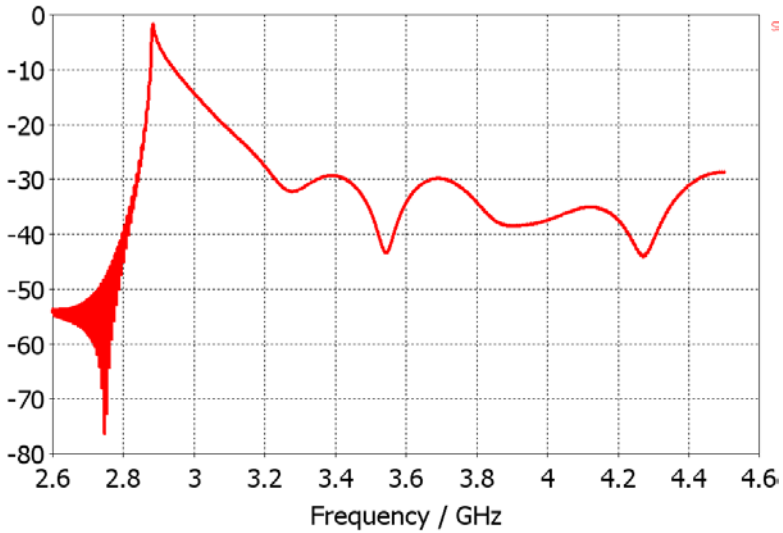
# Summary

- Heavy damping is required for the SPX cavities to maintain beam stability.
- Damper design is based on existing designs and has been enhanced to distribute the rf loading.
- HOM damper will be in-vacuum and will be located in the cryomodule.
- LOM window option is being pursued with an external rf damper load located outside of the vacuum vessel.
- SPX damper designs show good rf and mechanical properties.

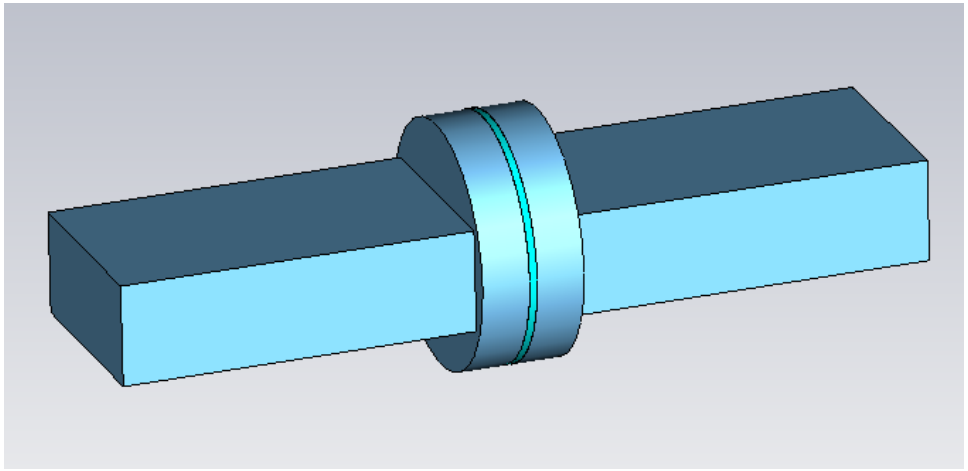
# BACKUP SLIDES

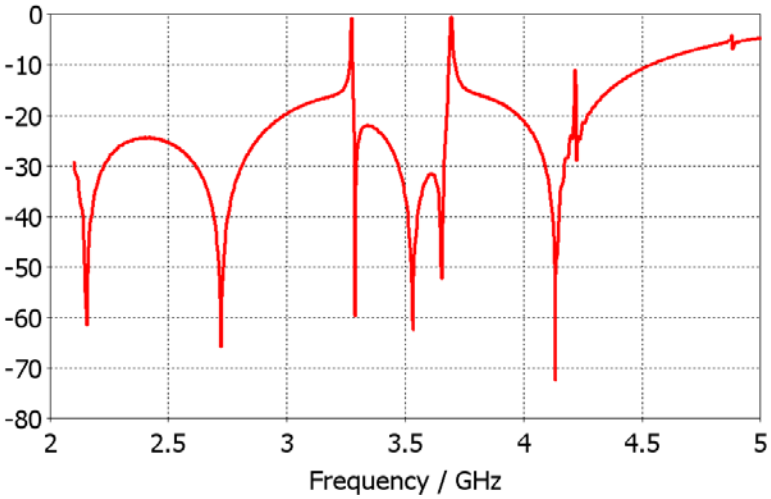
# HOM Assembly Without Ridges

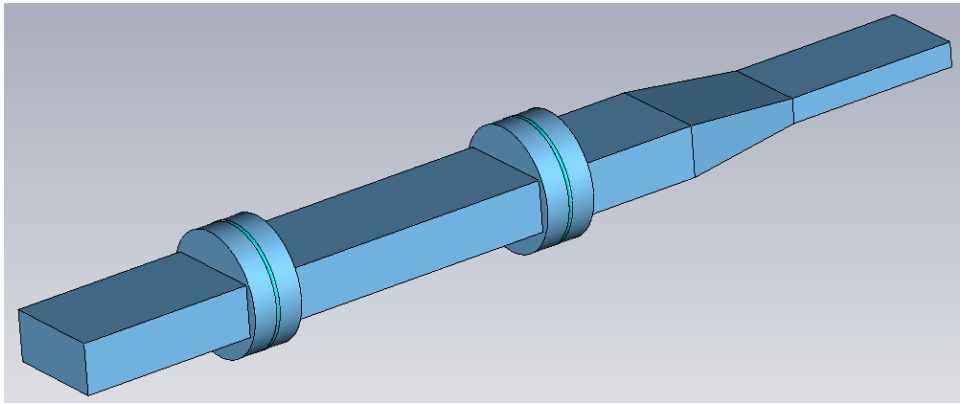


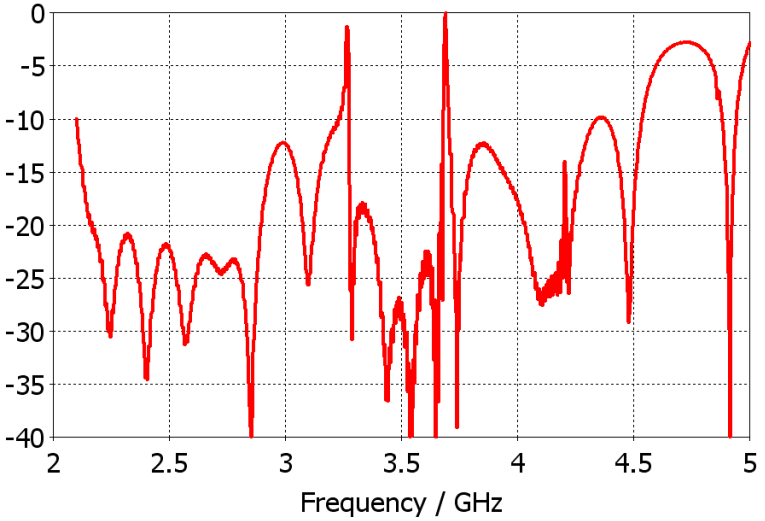


# LOM Window



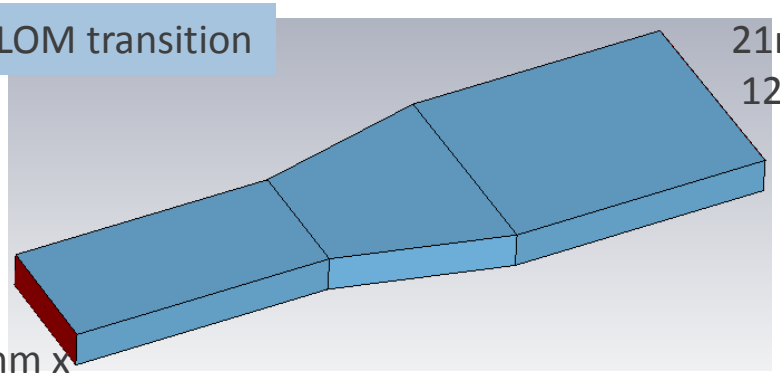

0
-10
-20
-30
-40
-50
-60
-70
-80
2
2.5
3
3.5
4
4.5
5
Frequency / GHz




0
-5
-10
-15
-20
-25
-30
-35
-40
2
2.5
3
3.5
4
4.5
5
Frequency / GHz

# Original HOM / LOM Damper Transitions

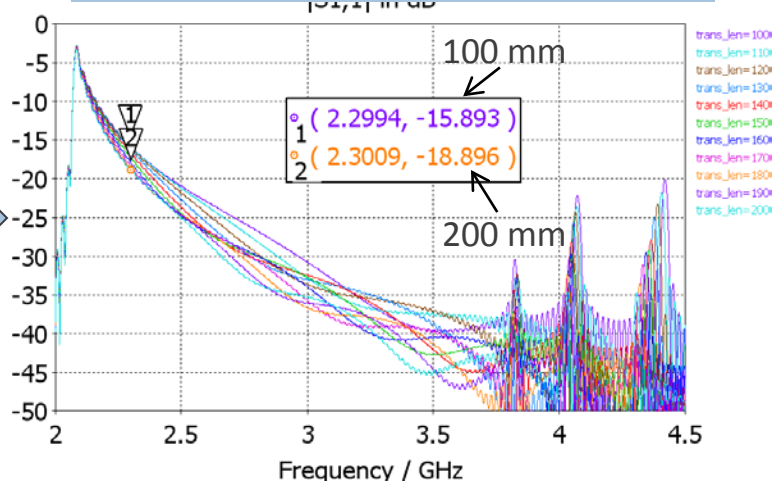
LOM transition



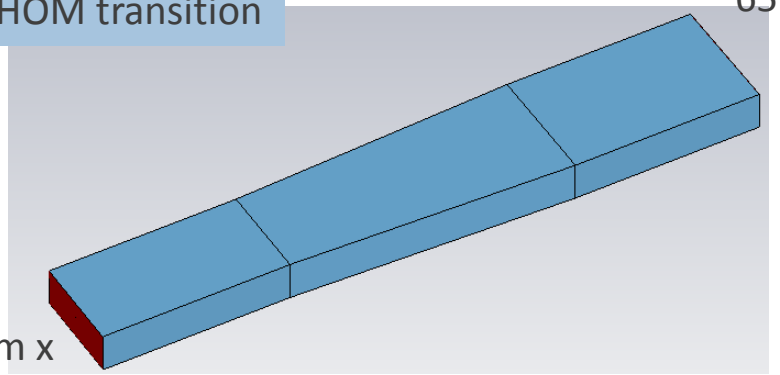
21mm x 120mm

21mm x 72mm

100mm to 200mm long transitions



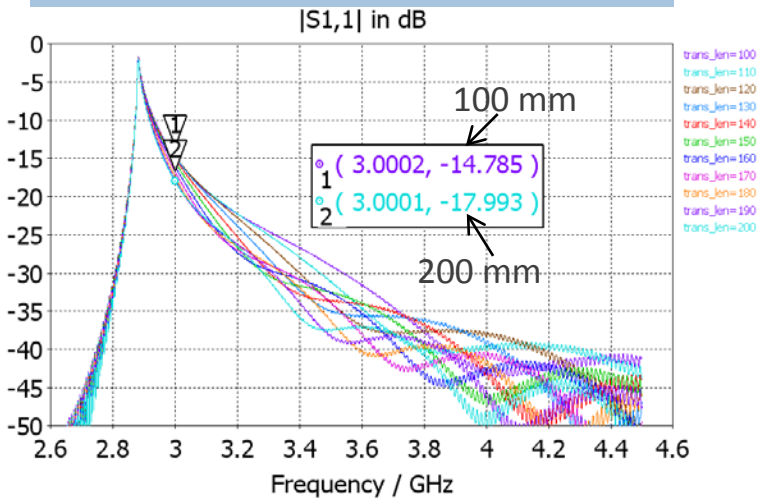

HOM transition



21mm x 65mm

21mm x 52mm

100mm to 200mm long transitions



# Damper Testing

- Low-power test for broadband rf performance.
- Copper cavity beadpull test to verify modal spectrum and damping performance
- Braze qualification test will consist of x-ray or ultrasound testing of braze joint, hot-plate test, peel test, … , and high-power rf cycling test.

- Particulate test will evaluate suitability of material near an SC cavity.
- High-power test will test and condition the damper up to 2kW.
  - LOM damper will be tested at 2.8GHz
  - HOM damper waveguide cutoff frequency is 2.9GHz.
- Dampers may be tested by JLAB on alternate cavity prototype?