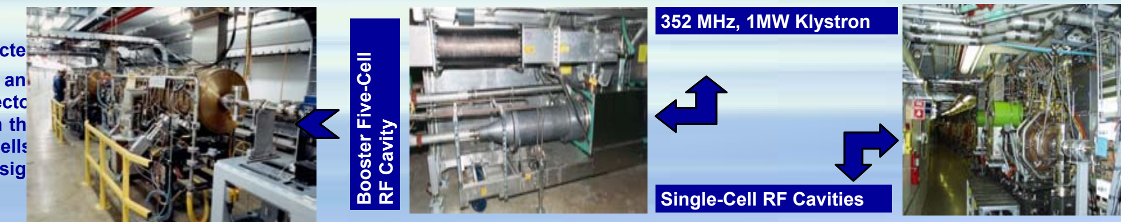
A SUMMARY OF THE ADVANCED PHOTON SOURCE RF COMPONENTS MODELING AND DEVELOPMENT ACTIVITIES

Radio Frequency and Mechanical Groups - Accelerator Systems Division

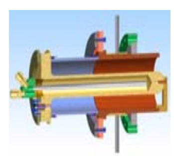
The **A**dvanced **P**hoton **S**ource (APS) at Argonne National Laboratory is a national user facility for synchrotron x-ray research constructe by the U. S. Department of Energy. It is a third-generation synchrotron radiation source specifically designed to accommodate insertion devices an beamlines from bending magnet radiation sources. The storage ring is designed to operate at 7 GeV with a full energy positron injector. The injecto booster synchrotron consists of a single 1-MW klystron which drives four five-cell cavities at 352 MHz. These cavities are identical to those used in th ESRF(Grenoble, France) and LEP (CERN, Geneva, Switzerland) storage ring. The storage ring cavities consist of four groups of four single cells powered by two 1-MW klystrons for 100-mA operation. Two additional 1-MW transmitters are added to the existing system to support the ultimate desig goal of 300-mA at 7 GeV. At least three transmitters are needed for 300-mA operation, affording one hot spare for 300-mA operation.



HIGH POWER RF COUPLER IN USE AT APS

- Transfers RF power from the source (klystron) to the accelerating cavity through a dielectric window.
- Provides an air-to-vacuum interface.
- Handles a nominal power of 100 kW CW for a 100-mA storage ring operation.
- Ceramic interface is Ti coated to suppress secondary electron emission.


Input RF Coupler.


3-D Model of Input RF Coupler.


Coupler Ceramic Window.

Failed Ceramic Window Due to Copper Coating.

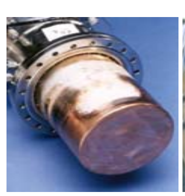

In-House Titanium Inner Surface Coating of the Ceramic Window (30 – 35 Angstroms).

HIGH POWER RF TUNER

- Thermal expansion of copper accelerating cavity will change its resonance frequency.
- Plunger-type tuner (via feedback control) keeps cavity on its resonance frequency.

Causes of Damage:

- Poorly aligned tuner piston.
- Non-uniform piston-housing gap.


Original Damaged Tuner.


Damaged RF Cavity Port.

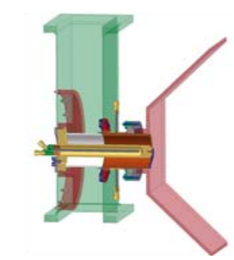

Damaged Ti-Coated Tuner (Piston Not Centered).

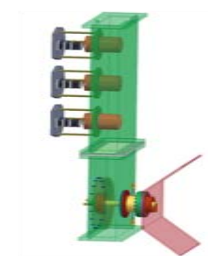
Solutions:

- Precision mechanically aligned tuner piston.
- Re-machined housing/piston gap.
- Titanium coated tuner piston to prevent RF breakdown.

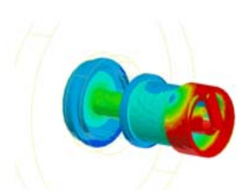
ALTERNATIVE RF COUPLER DESIGN IDEAS

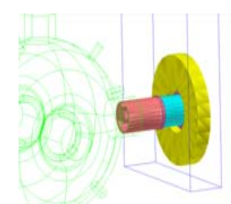
- Provide flexibility in source-to-cavity coupling factor adjustment.
- Real-time source-to-cavity coupling adjustment without breaking vacuum seal.
- Explore alternative geometries to improve power handling capability.
- Configuration optimization to reduce RF breakdown.

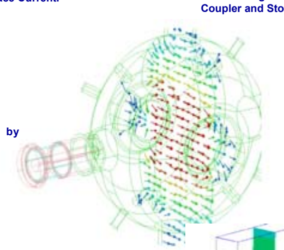

In-vacuum Adjustable Coupler Using Bellow.

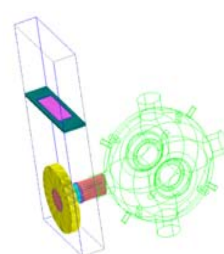

Adjustable Coupler Using Post Tuners in the Waveguide.

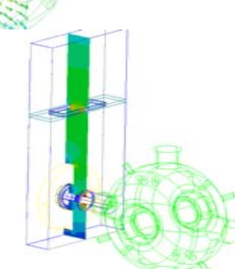
3-D Modeling and Fields Analysis


Input Coupler Surface Current.


3D Modeling of Rectangular Waveguide, Coupler and Storage Ring RF Cavity.

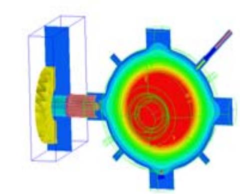

Fields Produced Inside Cavity by Input Coupler Excitation.

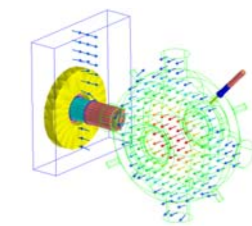

Ceramic Interface is Relocated Inside the Waveguide.

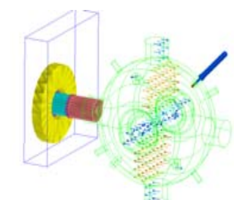

Electric Field Along the Transmission Line.

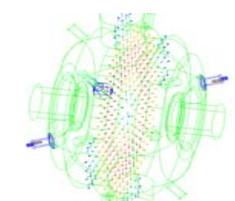
HIGHER ORDER MODE (HOM) DAMPERS

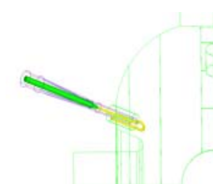
- The Purpose of mode damping is to extract and dissipate RF power at a specific frequency into a RF matched load.
- RF cavity higher order mode excitation causes stored beam to become unstable.
- Damping of the undesired mode is necessary for longitudinal beam stability.
- HOM damping is especially necessary for storage ring higher beam current operation (>200 mA).

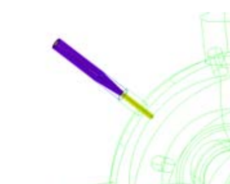

Magnitude of Electric Field at 352 MHZ.

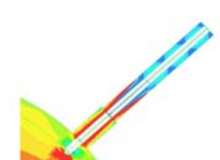

Electric Fields in the RF Cavity with Input Coupler and Mode Damper.

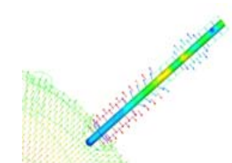

Magnetic Field Inside Cavity and Surface Current on the Damper at 352 MHz.


Excitation of 535 MHZ by Two H-Loop Probes.

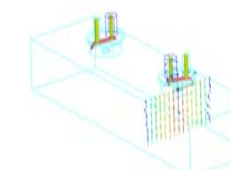

A Close-Up View of Magnetic Loop (H-Loop) Damper.

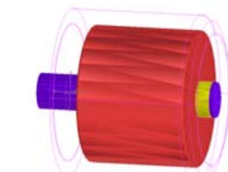

A Close-Up View of An Electric Field (E-Probe) Damper.

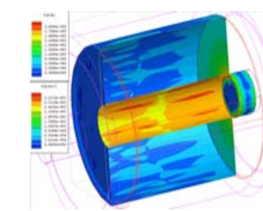

Power Coupling From Cavity to Damper at 535 MHZ.

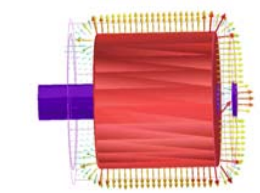

Electric Field Vector Around Damper and Surface Current Along Probe at 535 MHz.

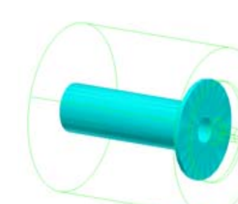
OTHER RF COMPONENTS MODELING

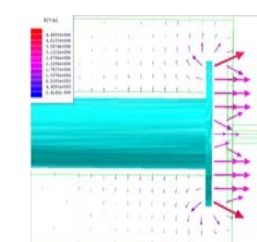

APS Linac Waveguide-Type Bi-Directional Coupler for Precision Measurement of Forward and Reflected RF Power.

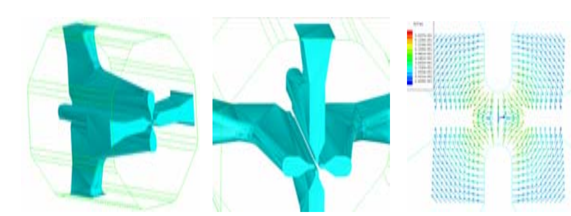

Electron Accumulation Ring Folded-Coaxial RF Fundamental Cavity Operating at 9.7 MHZ.


Surface Current Density Distribution Inside the Fundamental Cavity.


Field Distribution Inside the Fundamental Cavity.


A New Harmonic Coaxial Cavity Design for Storage Ring Direct Injection at 58 MHz. (Bypassing Accumulation Ring).


Electric Field Distribution Inside Harmonic Cavity.


A B C

A 57.5 MHz Radio Frequency Quadrupole (RFQ) Injector Resonator for the **R**are **I**sotope **A**ccelerator (RIA) Project. A) Cavity Geometry. B) Close-Up of the 4-vanes Resonator. C) Fields Distribution.

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