Dielectric Gas-filled RF Cavity

Muon Accelerator Program

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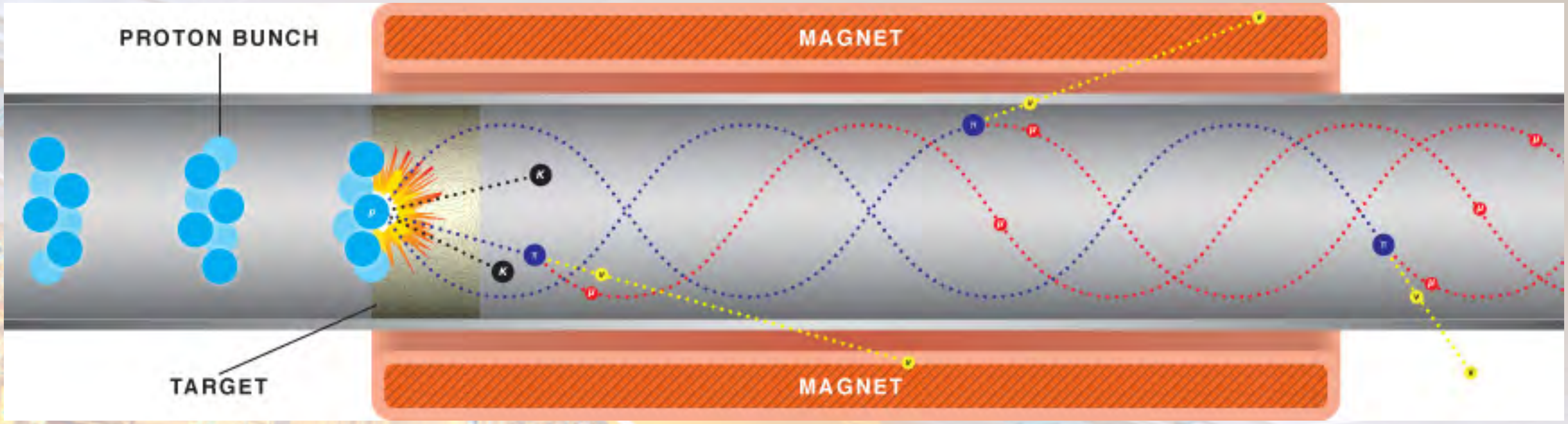
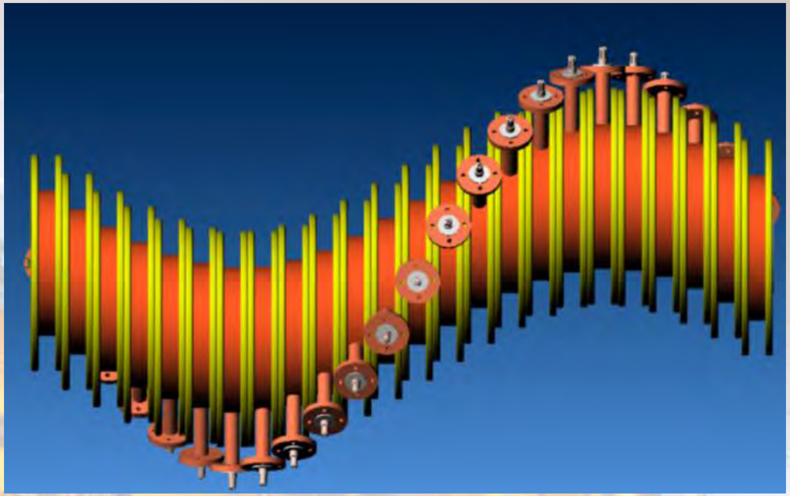
Muon Accelerator



- Advantages
  - Clean collision events
  - Low synchrotron radiation
- Constraints
  - Tertiary particle
  - Short life time

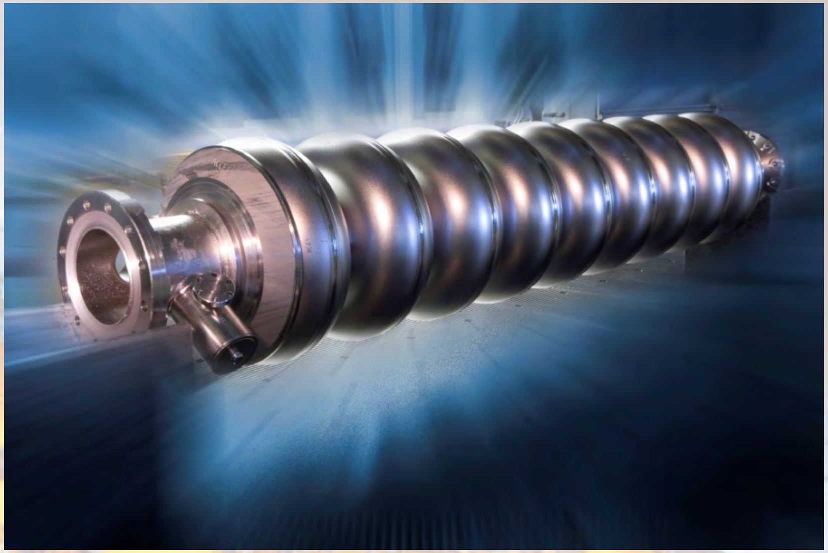
Cooling Process

- Helical Cooling Channel (HCC)
  - Magnetic solenoid & ionization cooling structure
  - Particle energy loss depends on momentum - Emittance exchange



- Challenge
  - Incorporating RF cavities into the magnet

Radio Frequency (RF) Cavities



- Utilize radio frequency power to accelerate particles
- Resonant frequency depends on geometry and material of the cavity
- For a simple pillbox cavity:

$$f = 2.405 c / 2\pi R \sqrt{\mu\varepsilon}$$

- When considering the cavity as an LCR circuit:

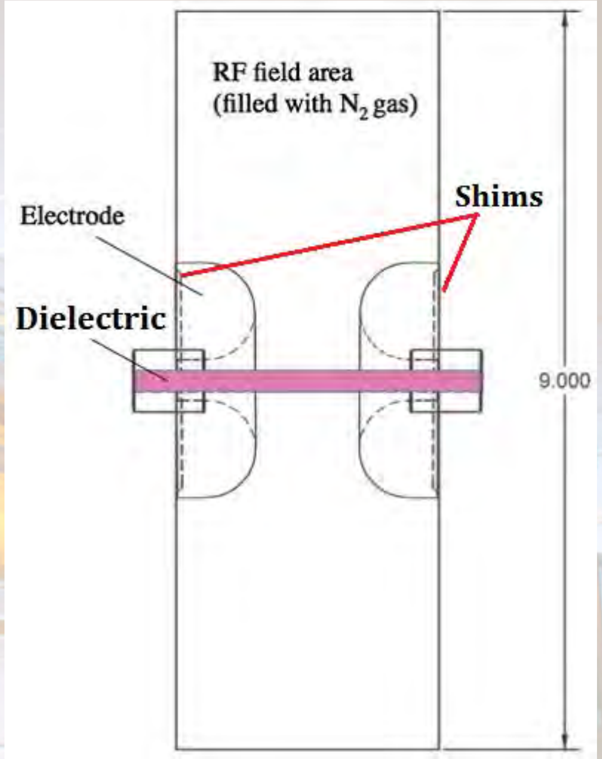
$$f = 1 / 2\pi \sqrt{LC}$$

Dielectric Loaded Gas-filled RF Cavity

- The size of a vacuum cavity is too large for HCC magnetic solenoid
- Propose to insert a dielectric material to reduce size
- Dielectric material can induce surface breakdown process
- Utilize buffer gas to eliminate surface breakdown
- A test cell has been built to verify this model

Baseline Design

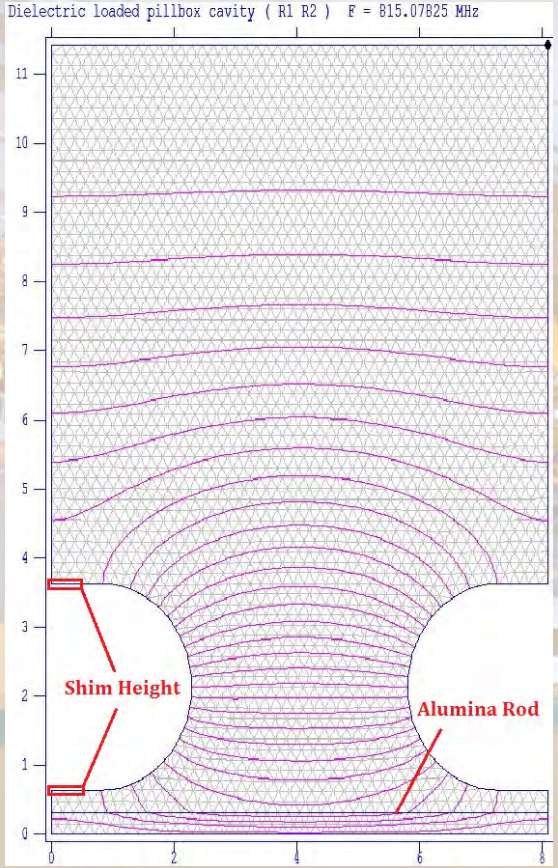
- Copper shims beneath electrodes
  - Serve to adjust frequency
- Different dielectric materials are tested
  - Alumina ceramic & Teflon
- Software Superfish is used to simulate the test cell
- Adjust shim height to shift frequency



Property	Teflon	Alumina	Unit
Length	4	4	Inch
Width (Diameter)	0.25	0.25	Inch
Relative Dielectric Constant	2.1	9.6	
Loss Tangent	2.80E-04	1E-4	
Dielectric Strength	23.6	16.7	MV/m

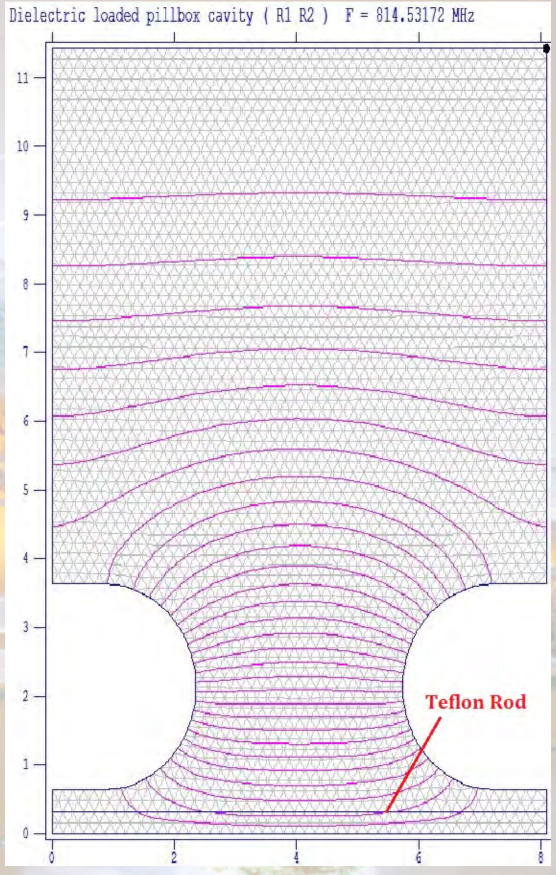
Baseline Design Results

Alumina ceramic



Shim Height = 0.04 cm

Teflon

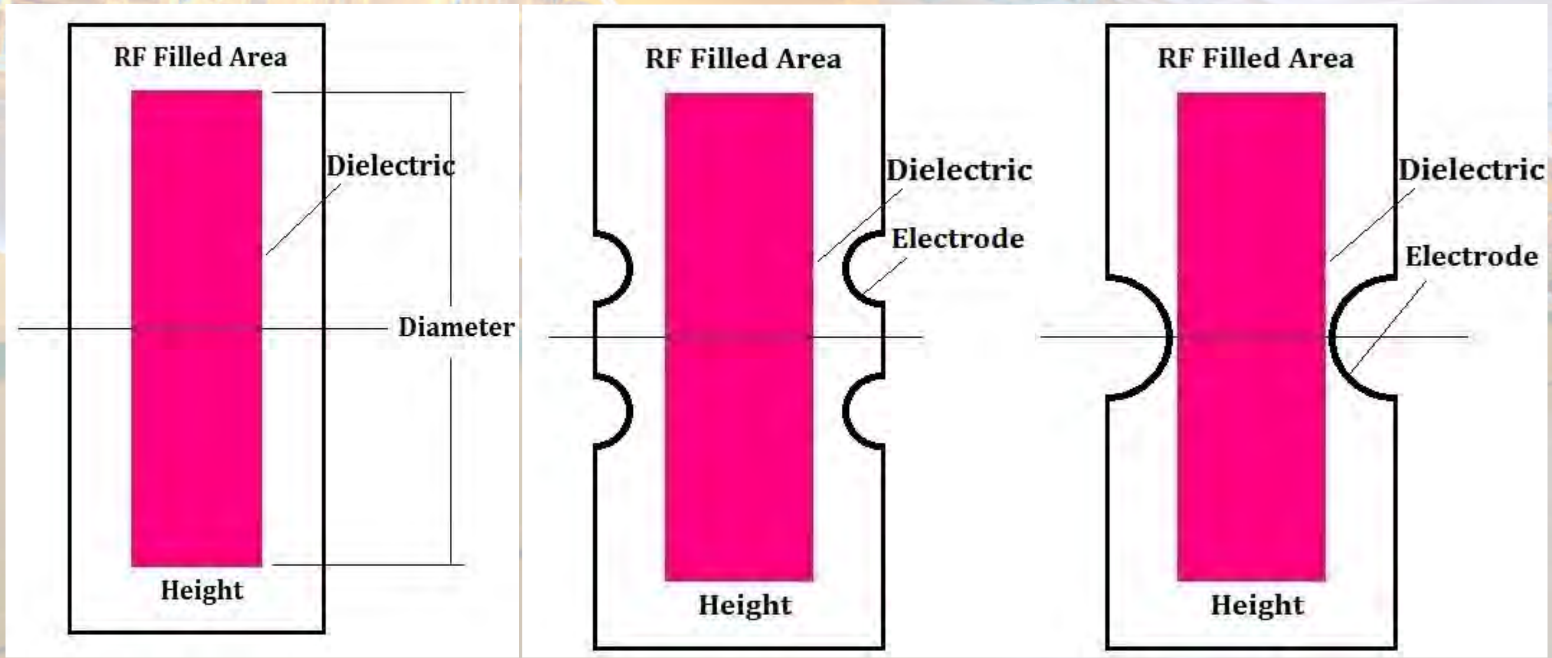


Shim Height = 0.1065 cm

Disk Design

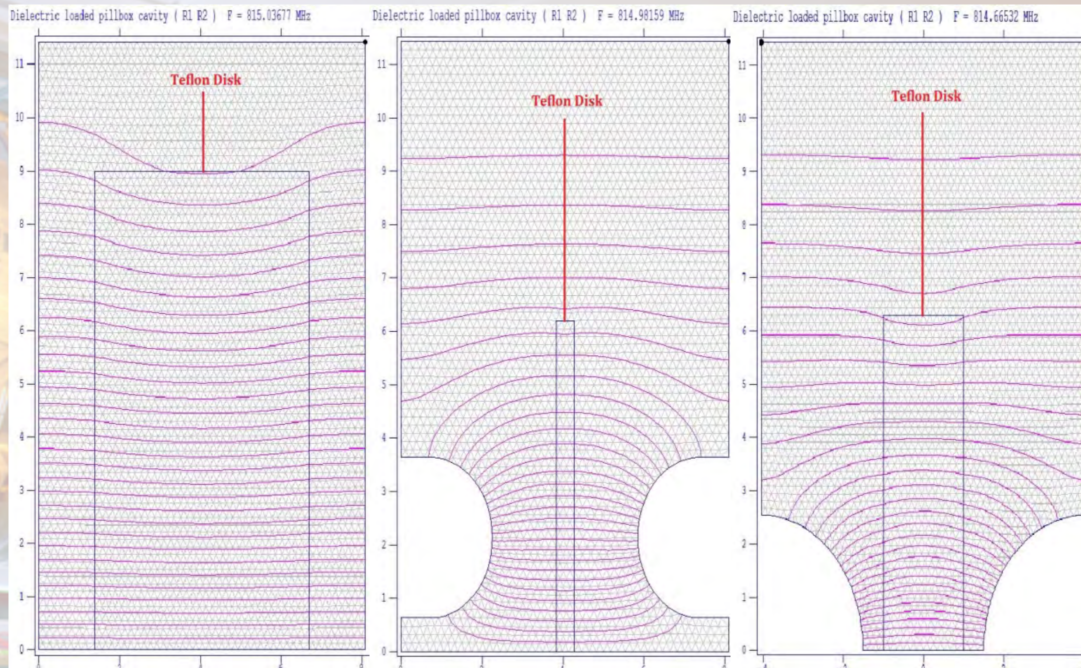
- ❖ Different electrodes & Materials
  - Donut/ Hemisphere electrode
  - Alumina & Teflon

- ❖ Adjust the size of disk to achieve resonant frequency



Disk Design

Alumina Ceramic
Teflon



	Test #1	Test #2	Test #3
Material	Teflon	Teflon	Teflon
Electrode	None	Donut	Hemisphere
Diameter(cm)	18	12.4	12.6
Height(cm)	5.295	0.44	2

Future Plan

- Design a new shim
  - Current shim has a dielectric breakdown at 20MV/m
  - Higher dielectric strength expected for new shim – 50MV/m
- Test new materials
  - TiO
- Experimentally verify the results in the test cell

Questions?