Loaded Pillbox Cavity

Milorad Popovic

(with Mike, Chuck, Katsuya, Al and Rol)

Motivation

To fit pressurized cavities in HCC, size of cavity has to be reduced

800 MHz (from Katsuya)

- Maximum RF cavity radius = 0.08 m, (pillbox cavity 0.143)
- Radius of effective electric field (95 % from peak) = 0.03 m

400 MHz:

- Maximum RF radius = 0.16 m (pillbox cavity 0.286)
- Radius of effective electric field = 0.06 m
- Optimum electric field gradient = 16 MV/m

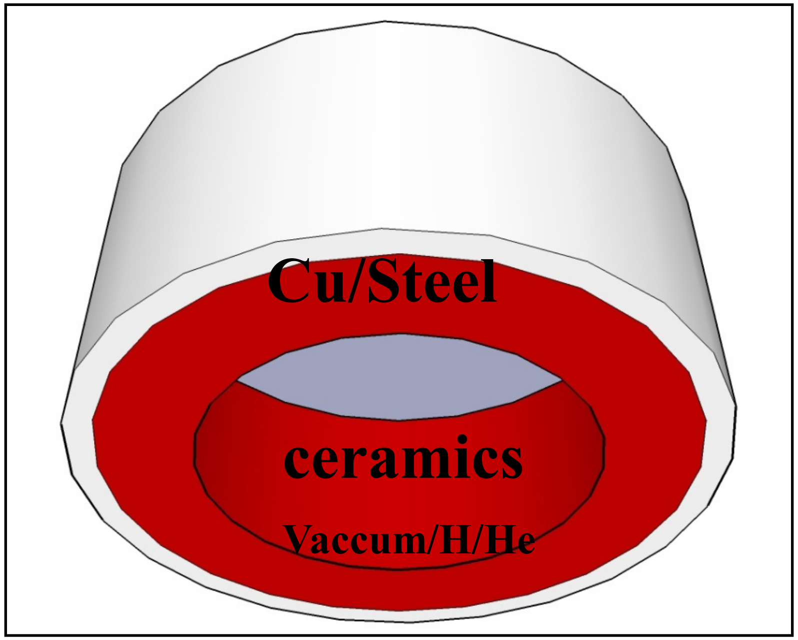
For Pill Box Cavity, resonant frequency is

$$\omega = \frac{2.405c}{R\sqrt{\varepsilon_r \mu_r}}$$

Dielectric Loaded RF Cavities

New type of cavity is suggested.

The idea came from conversation with Chuck and Yonehara.



I was told that Al suggested something like this.

Muons, Inc.

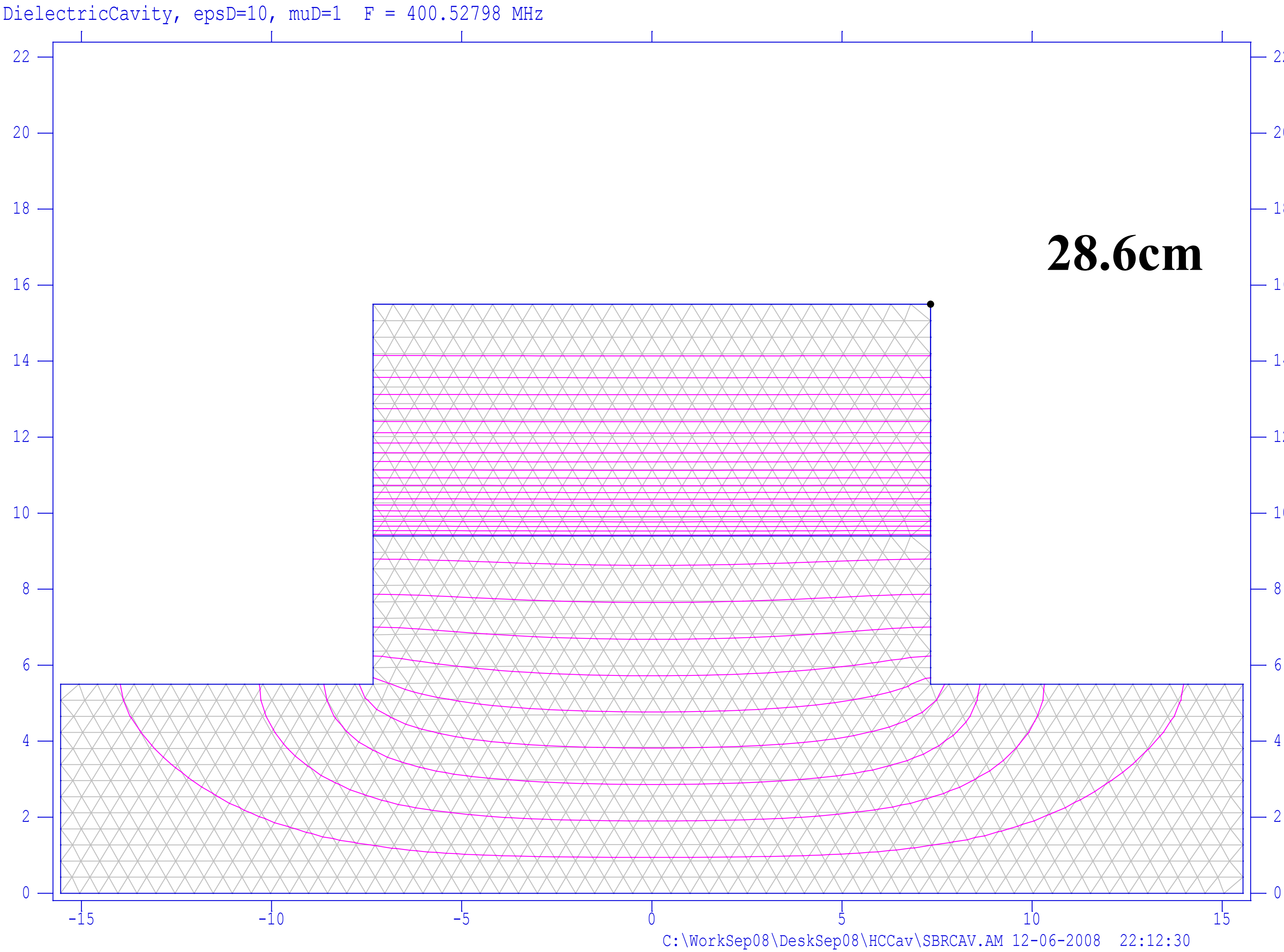
SuperFish Model

14.3cm

DielectricCavity, epsD=10, muD=1 F = 814.12558 MHz

C:\Documents and Settings\popovic\Desktop\HCCav\SBRCAV.AM 8-06-2008 6:52:28

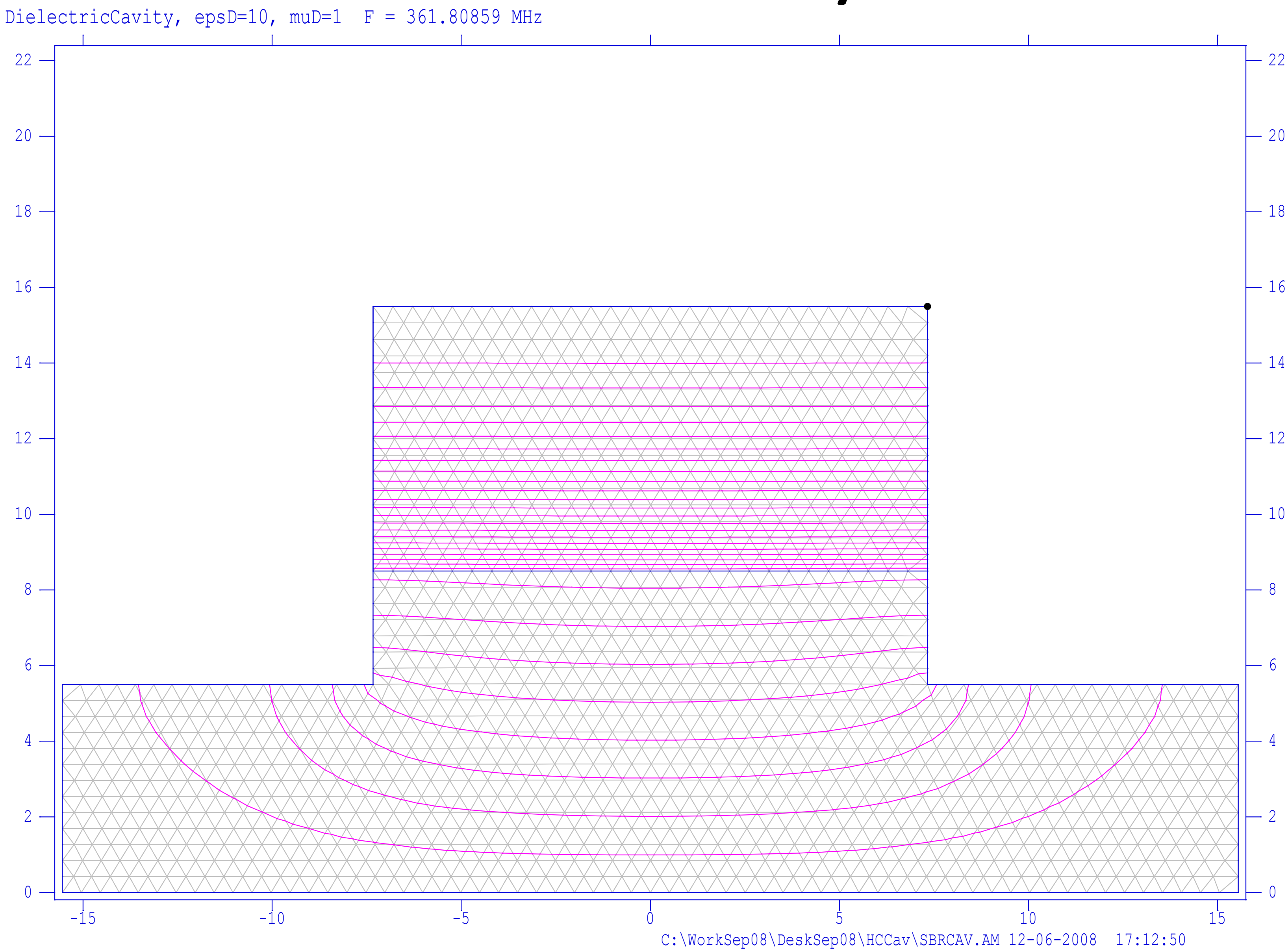
400MHz Cavity



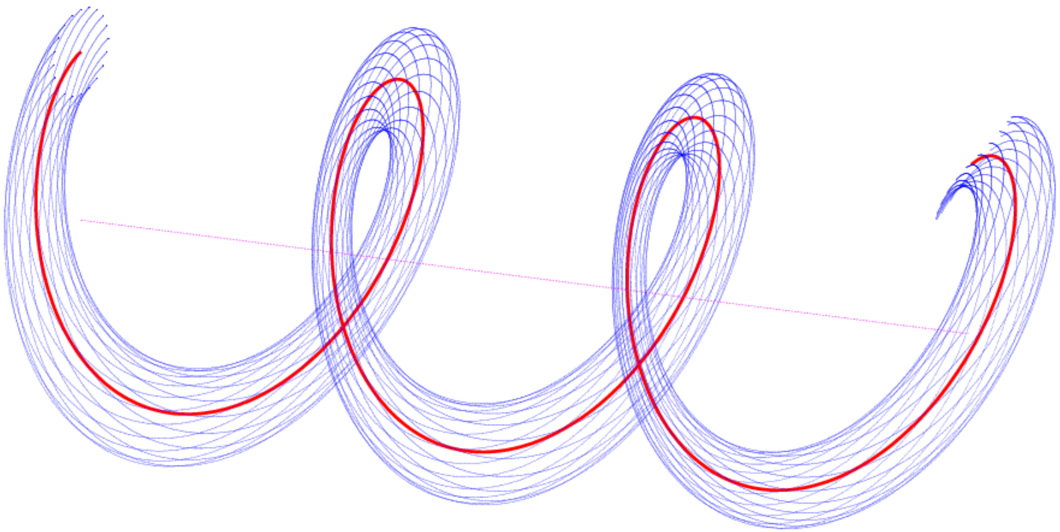
Muons, Inc.

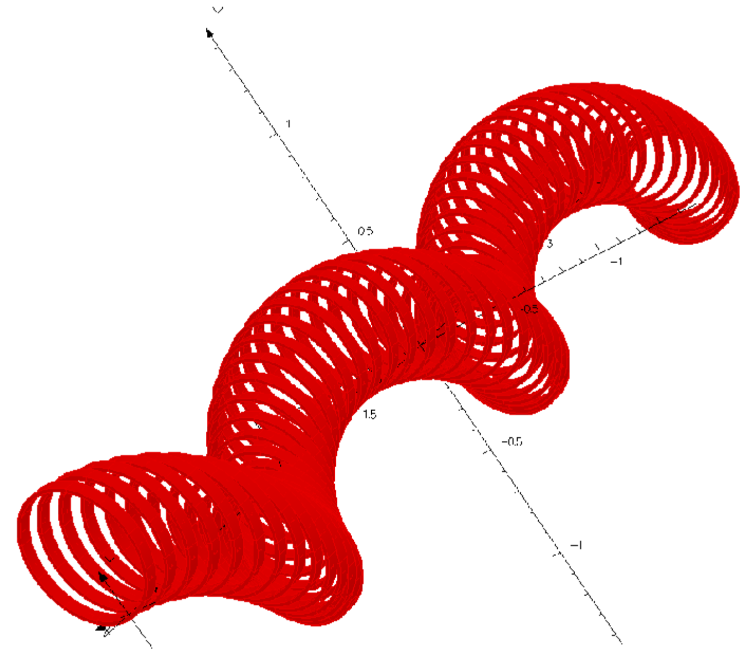
361MHz Cavity

Fermilab



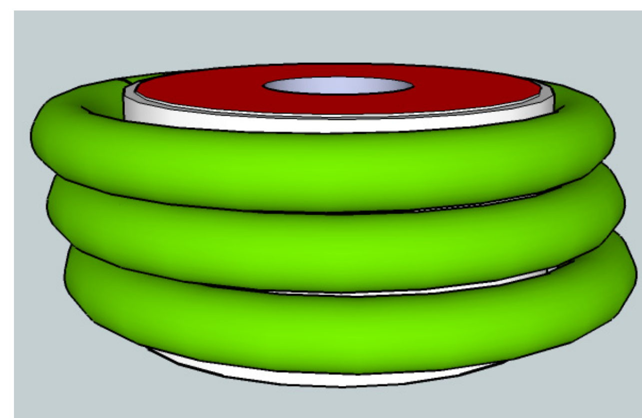
HCC Concept





Central Orbit and Beam Envelope

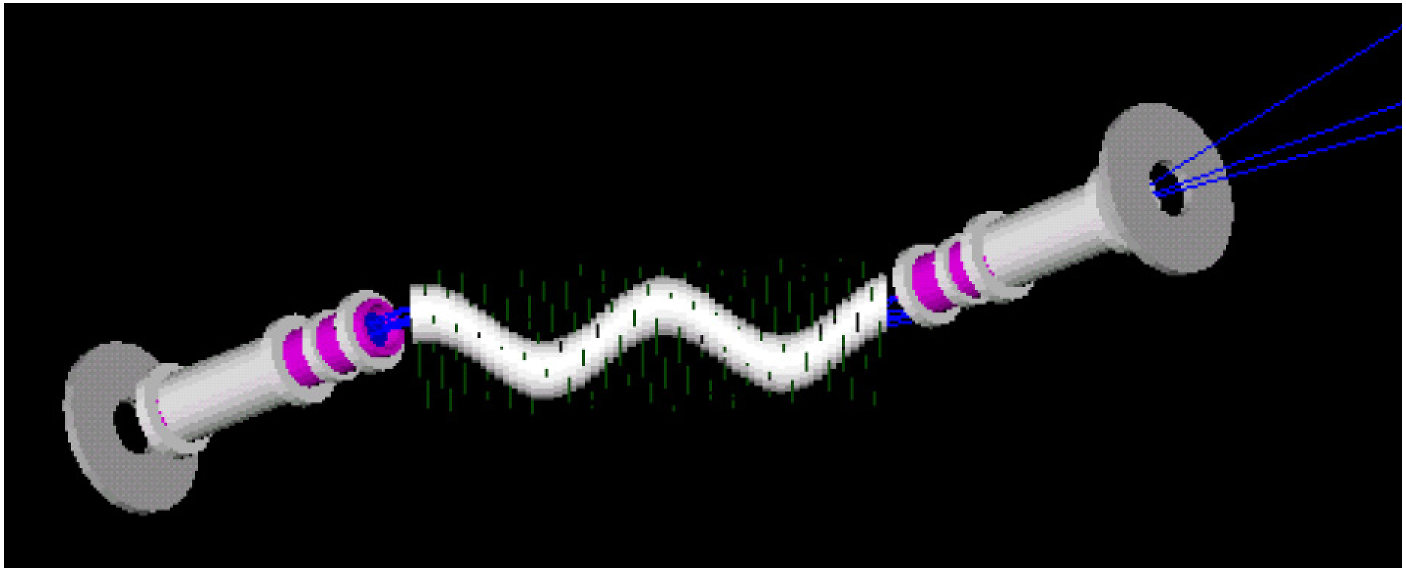
Set of Coils

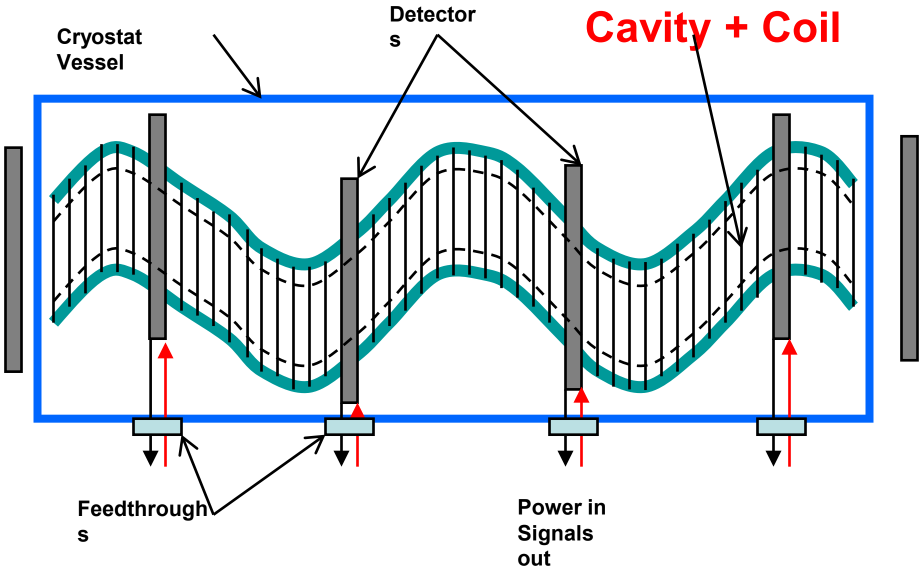


Basic Building Block can be Cavity + Coil

Muons, Inc.

MANX + RF ?



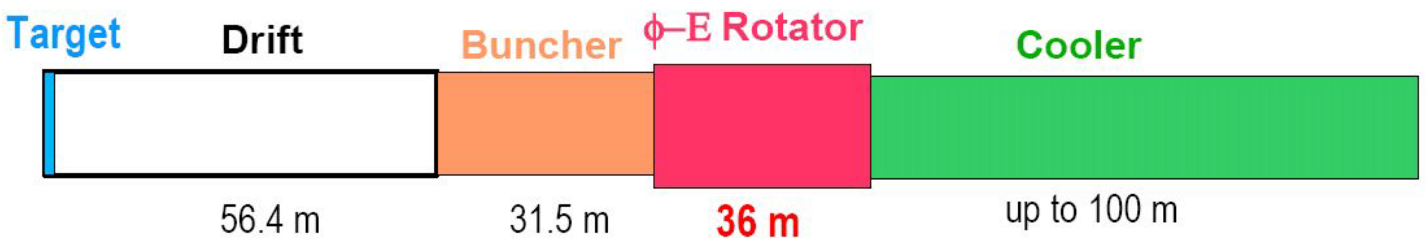


MICE will have ~?MV @200MHz

Other Applications

May be we can use this type of cavity for Neuffer's Phase Rotation Canal. This was Cary Yoshikawa suggestion. The canal needs many cavities in range from ~300 to 200MHz. We can use, let say two sizes of Pill Box Cavity (same size different dielectric!) and adjust frequency in between using different iner radius, re-entrant nose cones!

Cavities for Neutrino Factory



Schematic of the Neutrino Factory front-end transport system. Initial drift (56.4 m), the varying frequency buncher (31.5m), The phase-energy (ϕ-δE) rotator (36m) , a cooling section. (A 75m cooling length may be optimal.)

Parameter	Drift	Buncher	Rotator	Cooler
Length (m)	56.4	31.5	36	75
Focusing (T)	2	2	2	2.5 (ASOL)
Rf frequency (MHz)		360 to 240	240 to 202	201.25
Rf gradient (MV/m)		0 to 15	15	16
Total rf voltage (MV)		126	360	800

What is Next, 5-Years Plan

The projected funding for the 5-year program proposed here..

…We will also accomplish sufficient hardware R&D (RF, magnets, and cooling section prototyping) to guide, and give confidence in, our simulation studies.

In order to produce a practical helical cooling channel, several technical issues need to be addressed, including: magnetic matching sections for downstream and upstream of the HCC a complete set of functional and interface specifications covering field quality and tunability, the interface with rf structures, and heat load limits (requiring knowledge of the power lead requirements)

To prepare the way for an HCC test section we would:

Develop, with accelerator designers, functional specifications for the magnet systems of a helical cooling channel, including magnet apertures to accommodate the required rf systems, section lengths, helical periods, field components, field quality, alignment tolerances, and cryogenic and power requirements. The specification will also consider the needs of any required matching sections.

Perform conceptual design studies of helical solenoids that meet our specifications, including a joint rf and magnet study to decide how to incorporate rf into the helical solenoid bore, corrector coils, matching sections, etc.

Muons, Inc.

Fermilab

What is Next

SBIR

FIRM NAME: Muons, Inc.	RESEARCH INSTITUTION: Fermi National Accelerator Laboratory Milorad Popovic, subgrant PI
ADDRESS: 552 N. Batavia Ave. Batavia, IL 60510	ADDRESS:

Phase I-SBIR/STTR Fiscal Year 2009
(All information provided on this page is subject to release to the public.)
NAME of PRINCIPAL INVESTIGATOR: **Michael Neubauer** PHONE NUMBER: **(707) 360-5038**
PROJECT TITLE: **46a Dielectric Loaded RF Cavities**

Main Issues

Loss tangent $\tan \delta = 1/Q_{dielectric} - 1/Q_{air}$

Loss tangents of specially formulated alumina with TiO_2 have been reported to be close to sapphire at 1e-5 . So it is easy to see that today's ceramics may be used in this novel idea without suffering a great deal in cavity Q at low frequencies.

The other problem with ceramics in vacuum with beams is that of surface charging of the ceramic. And again, much work has been done in coatings, from Chromium Oxide to TiN to, more recently, ion implantation
Air gap between the dielectric and metal plates will be one of the issues that must be tested experimentally

- **May be ceramics can play additional role, making volume of Hydrogen smaller and making cavity stronger so the walls do not have to be as thick as without ceramics.**
- **RF power can be fed using loop between two rings.**
- **Cavities can be put next each other so the side wall can be made thin**
- **May be we should do experiment in the MTA, with solenoid!**

Ceramics EXIST!

Muons, Inc. | Fermilab

Ceramic properties
Alumina

AL-995™
(MAC-A995W)

Description

High purity alumina ceramic of **99.5% Al_2O_3** content. Its purity, chemical resistance and high temperature capabilities prove invaluable for semiconductor processing applications.

Prime features

- Electrically and dimensionally stable at high temperatures.
- Low particle generation.
- Dense, non porous and vacuum tight.
- Excellent dielectric properties.
- Accepts moly-manganese metallising for high temperature brazing of vacuum tight assemblies.
- Excellent chemical and abrasion resistance.

Typical applications

- Wafer processing and handling devices.
- Components for semiconductor process chambers, spluttering targets, fixtures, etc.
- Laser devices for wide range of industrial, medical and defence duties.
- Power tubes for klystron and x-ray equipment.
- Flow meters and pressure sensors.

Specifications

- Quality Assurance to ISO 9002.

MAC production capabilities

- Isostatic and dry pressing, green machining.
- CNC grinding and lapping to very tight tolerances.
- Metallising of components.
- High temperature brazing of assemblies.
- Prototype, batch and volume production.

Physical properties*

Color	White
Bulk density (fired), Mg/m^3 [lb/in^3]	3.86 [0.139]
Porosity (apparent), %	0 (fully dense)
Rockwell hardness (R45N)	81
Compressive strength, MPa [lb/in^2]	>2070 [>300,000]
Flexural strength, MPa [lb/in^2]	310 [45,000]
Thermal conductivity, W/m.K [BTU/ft.hr.°F] @RT	29.3 [16.9]
Thermal expansion coefficient, 10^{-6}/C [10^{-6}/°F]	
25-200C [77-390°F]	6.9 [3.8]
200-400C [390-750°F]	7.8 [4.3]
400-600C [750-1110°F]	8.3 [4.6]
600-800C [1110-1470°F]	9.0 [5.0]
800-1000C [1470-1830°F]	9.4 [5.2]
Maximum no-load temperature, C [°F]	1725 [3150]
Dielectric strength, dc kV/mm [V/mil] @RT	31.5 [800]

		25C	300C	500C
Dielectric constant, K^I,	@ 10MHz	9.58	9.92	10.20
	@ 1000MHz	9.30	—	—
	@ 8500MHz	9.37	9.61	9.82
Dissipation factor, tan δ,	@ 10MHz	0.00003	0.00009	0.00040
	@ 1000MHz	0.00014	—	—
	@ 8500MHz	0.00009	0.00014	0.00025
Loss factor, K^I tan δ,	@ 10MHz	0.00029	0.00089	0.00408
	@ 1000MHz	0.00130	—	—
	@ 8500MHz	0.00084	0.00135	0.00245

Volume resistivity, ohm.cm		
	@ 25C [77°F]	$>10^{14}$
	@ 300C [570°F]	2.0×10^{11}
	@ 600C [1110°F]	6.0×10^{8}
	@ 900C [1650°F]	2.5×10^{6}
Te value, C [°F]		>975 [>1790]

Morgan
MorganTechnicalCeramics
www.morgantechnicalceramics.com

Please note that all values quoted are based on test pieces and may vary according to component design. These values are not guaranteed in anyway whatsoever and should only be treated as indicative and for guidance only

29/10/2007

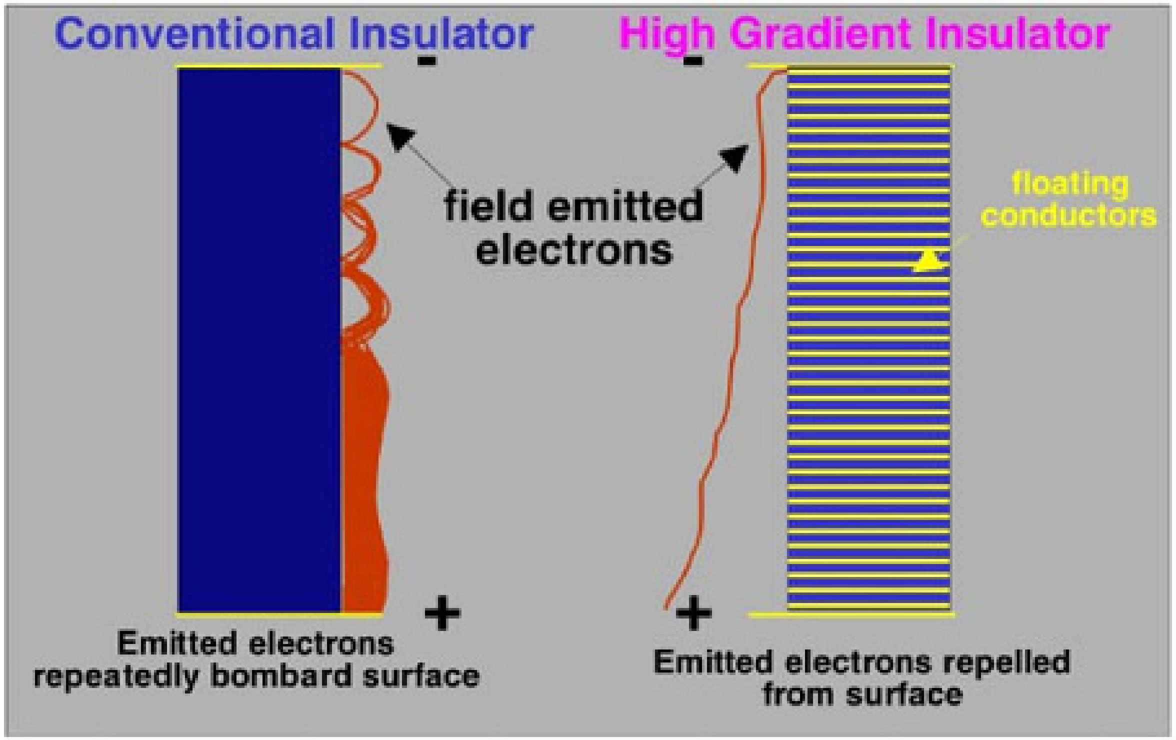
		25C	300C	500C
Dielectric strength, dc kV/mm [V/mil] @RT		31.5 [800]		
Dielectric constant, K^I,	@ 10MHz	9.58	9.92	10.20
	@ 1000MHz	9.30	—	—
	@ 8500MHz	9.37	9.61	9.82
Dissipation factor, tan δ,	@ 10MHz	0.00003	0.00009	0.00040
	@ 1000MHz	0.00014	—	—
	@ 8500MHz	0.00009	0.00014	0.00025

Proceedings of PAC07, Albuquerque, New Mexico, USA TUYC02

HIGH GRADIENT INDUCTION ACCELERATOR*,+

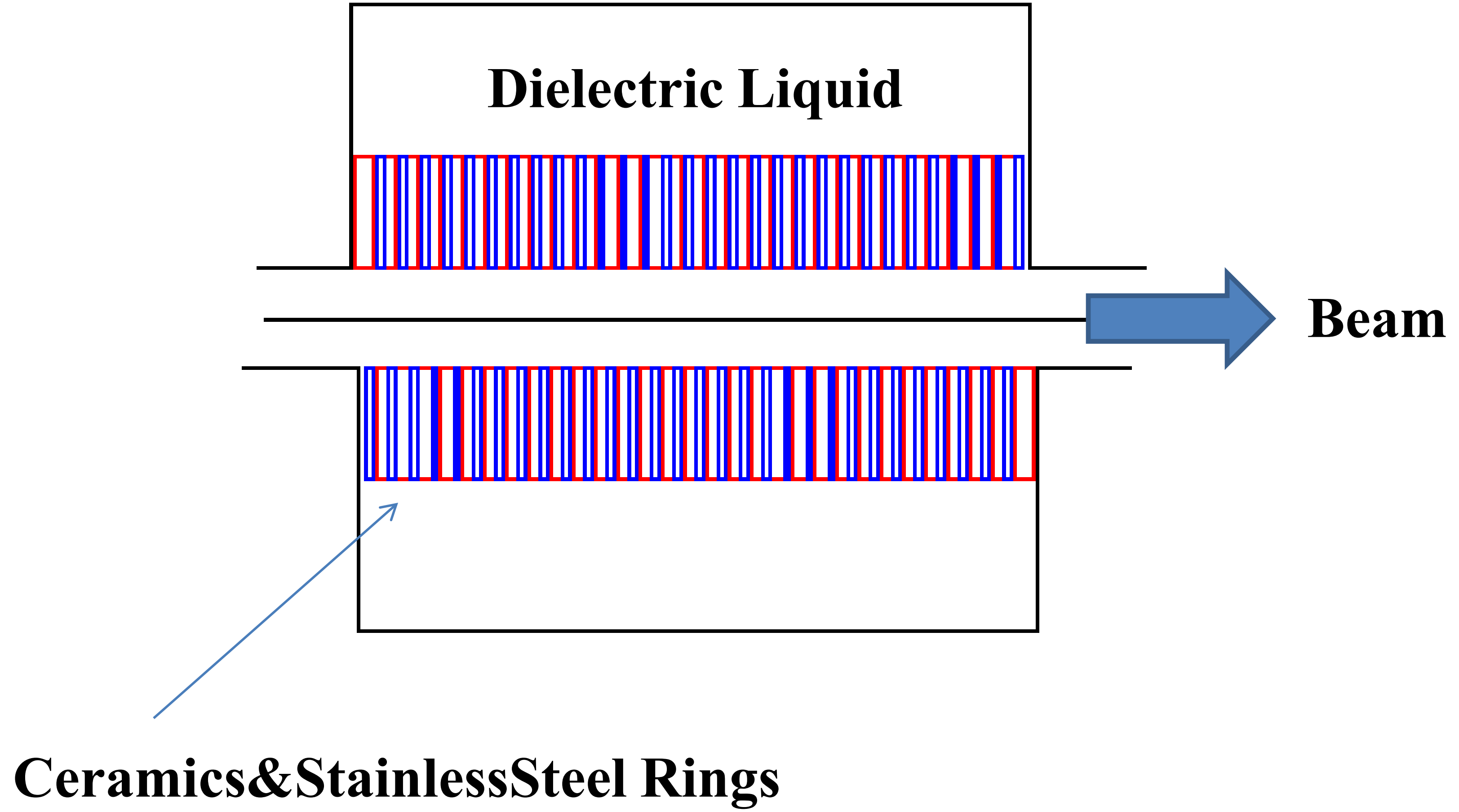
George J. Caporaso#, S. Sampayan, Y-J. Chen, D. Blackfield, J. Harris, S. Hawkins, C. Holmes, M. Krogh[a], S. Nelson, W. Nunnally[b], A. Paul, B. Poole, M. Rhodes, D. Sanders, K. Selenes[c], J. Sullivan, L. Wang, And J. Watson

Lawrence Livermore National Laboratory, Livermore CA 94551
[a]University Of Missouri, 1870 Miner Circle, Rolla, MS 67890
[b]University Of Missouri, Columbia, MS 65211
[c]TPL Corporation, 3921 Academy Parkway North NE, Albuquerque, NM 87109

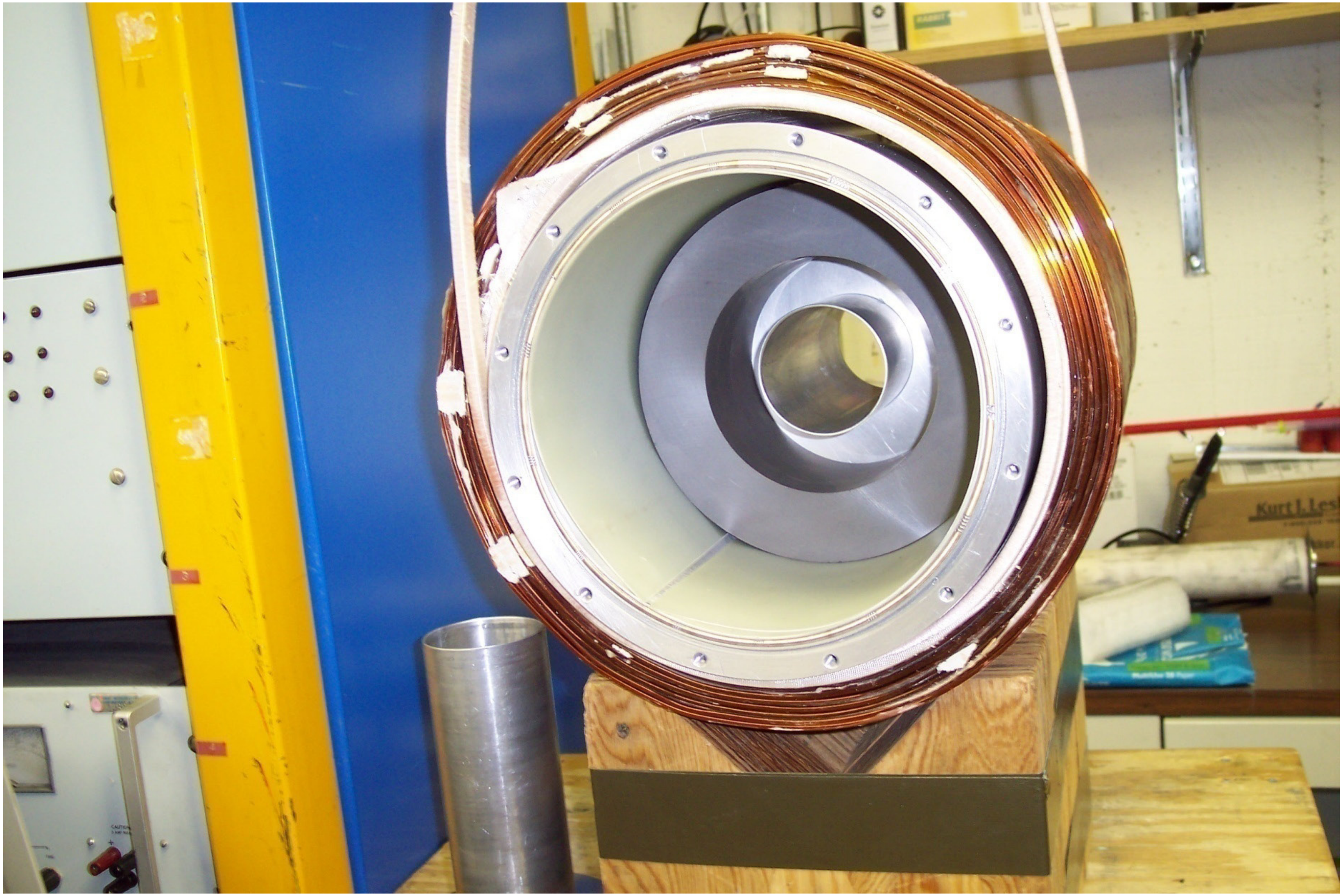


Ceramics for Gap

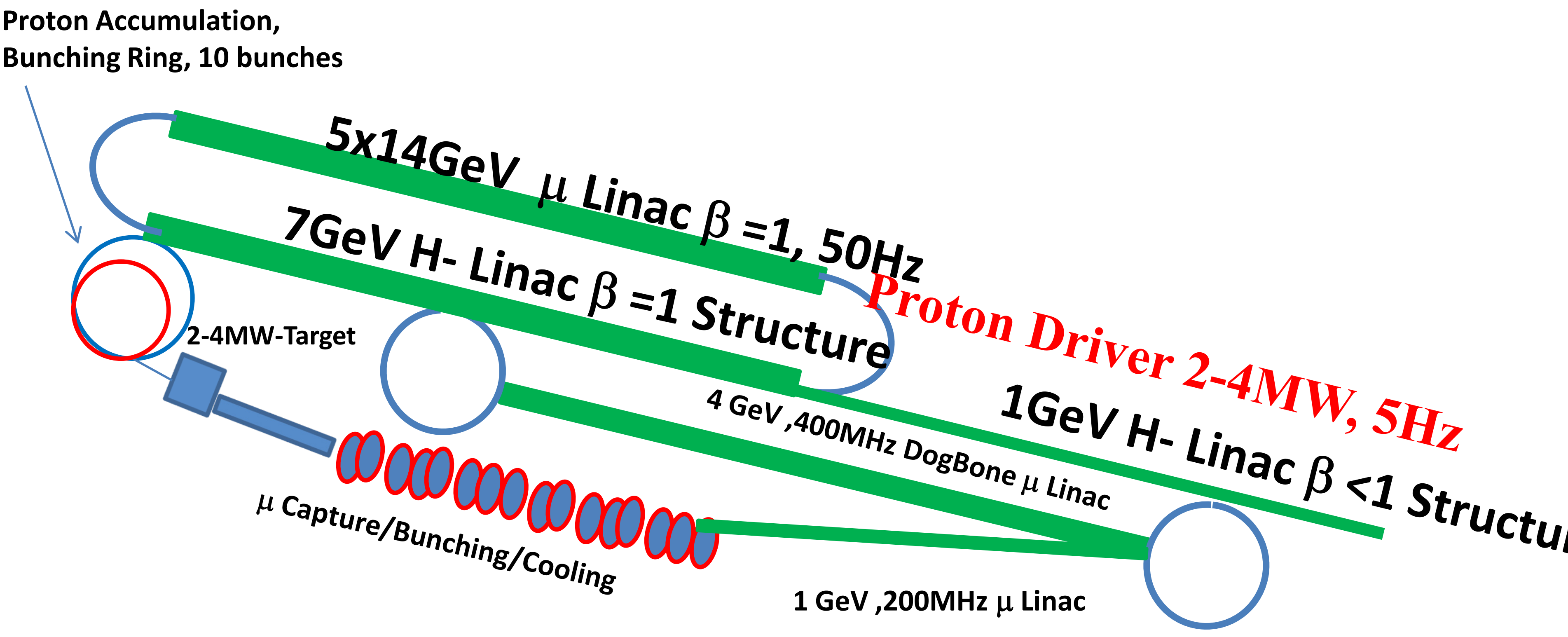
Vacuum Cavity for Phase Rotation

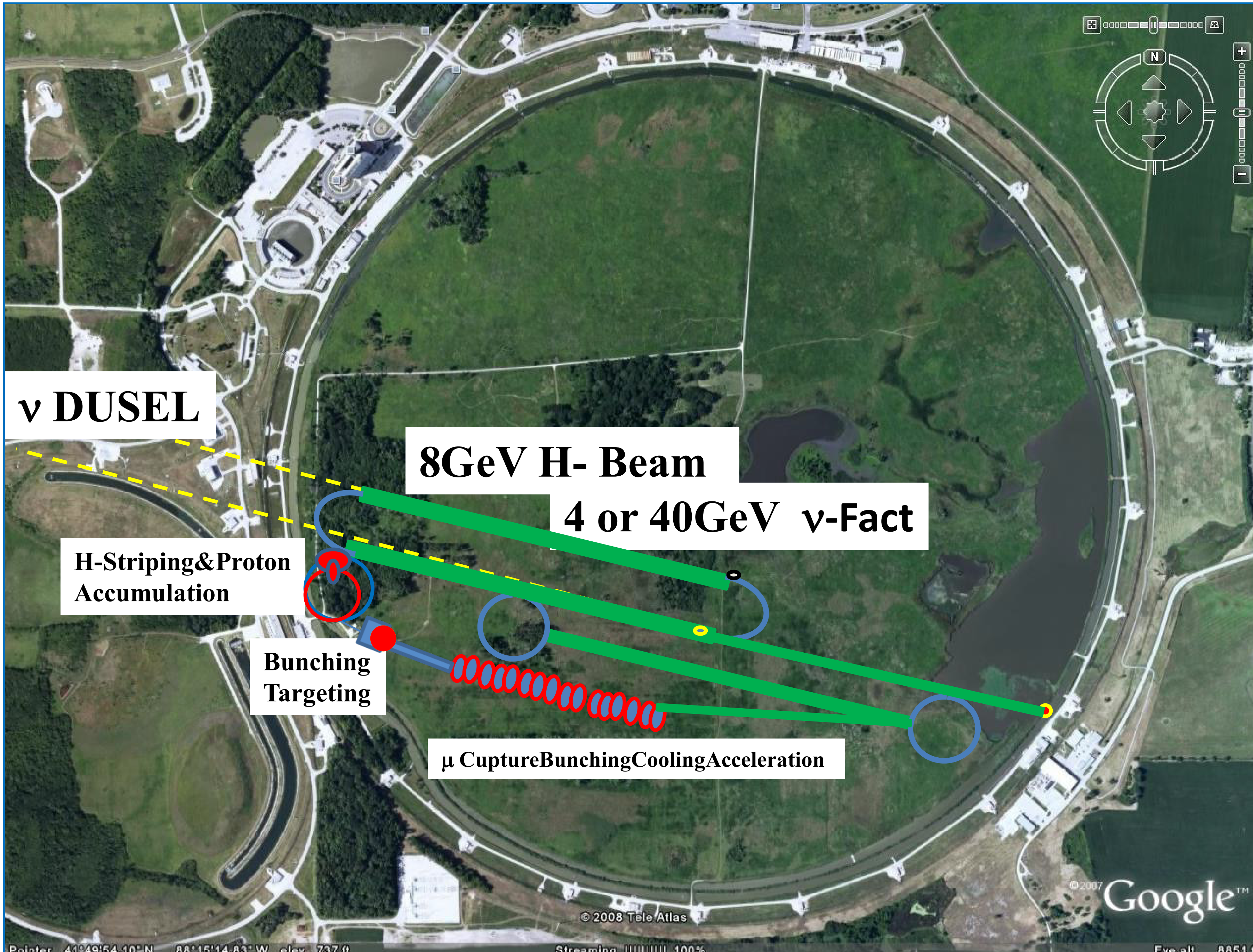


Test Cavity



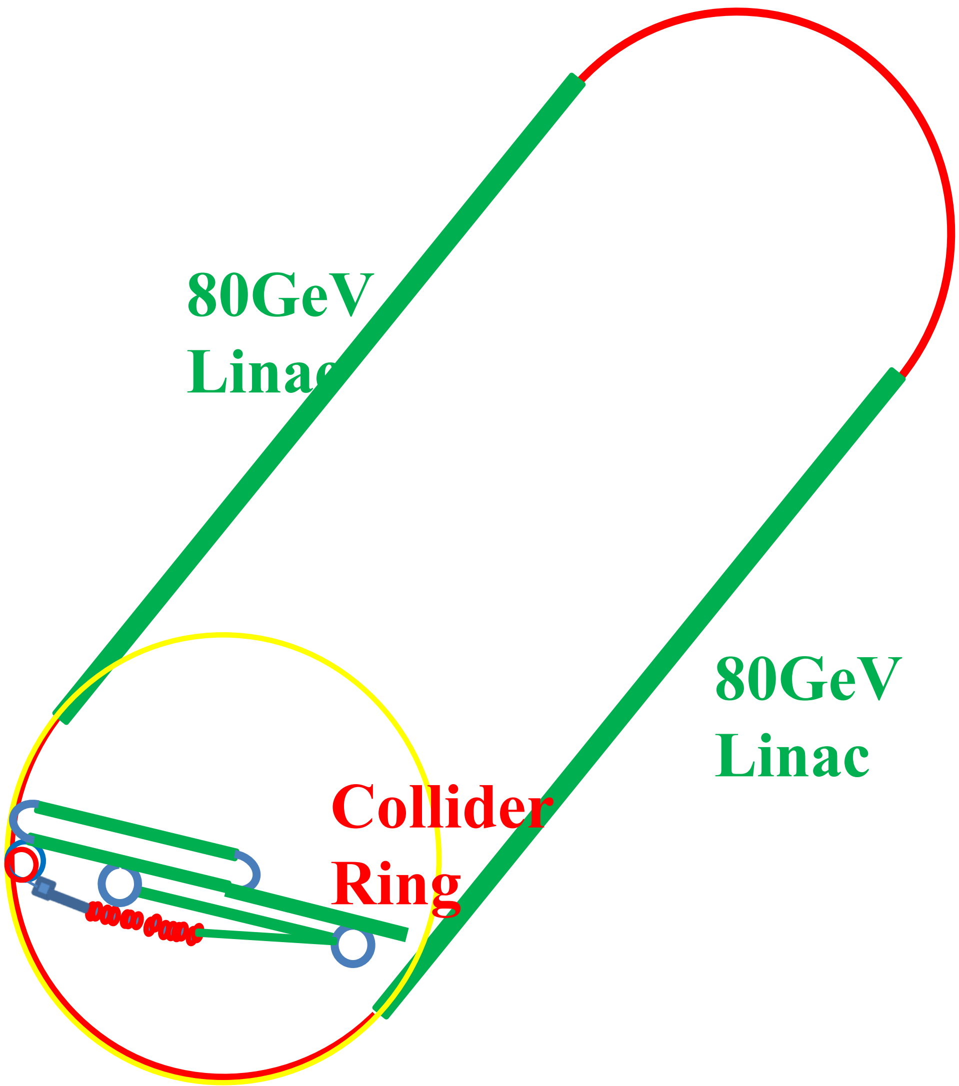
Neutrino Factory as 1st Step Toward Muon Collider

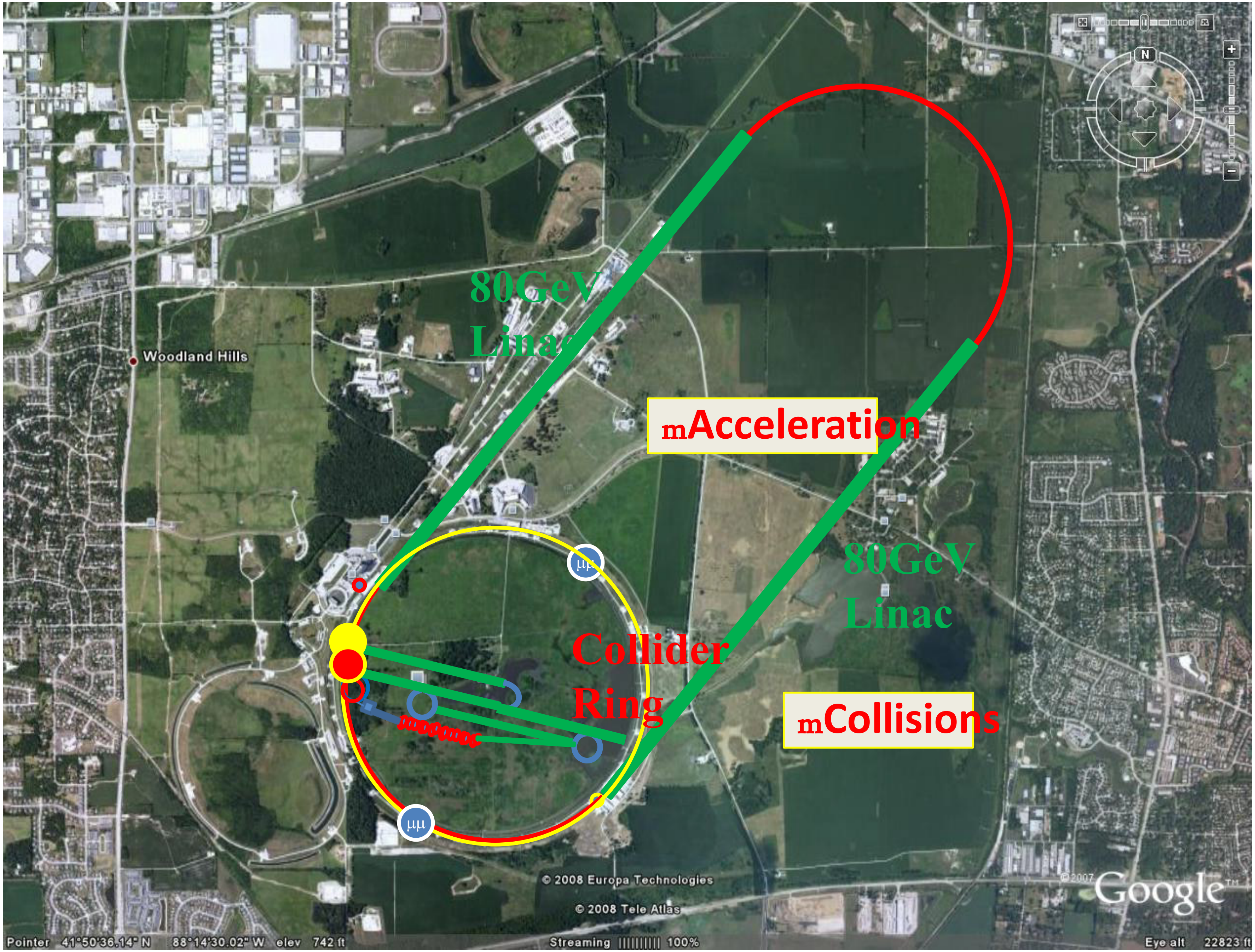




ν DUSEL
8GeV H- Beam
4 or 40GeV ν-Fact
H-Striping&Proton
Accumulation
Bunching
Targeting
μ CuptureBunchingCoolingAcceleration
© 2008 Tele Atlas
©2007 Google™
Pointer 41°49'54.10" N 88°15'14.83" W elev 737 ft
Streaming ||||||||| 100%
Eye alt 8851 ft

Muon Collider Stage




80GeV Linac
mAcceleration
80GeV Linac
Collider Ring
mCollisions
μμ
μμ
Woodland Hills
© 2008 Europa Technologies
© 2008 Tele Atlas
©2007 Google™
Pointer 41°50'36.14" N 88°14'30.02" W elev 742 ft
Streaming 100%
Eye alt 22823 ft