

Status and Plans for the 805 MHz Box Cavity

MuCool RF Workshop III

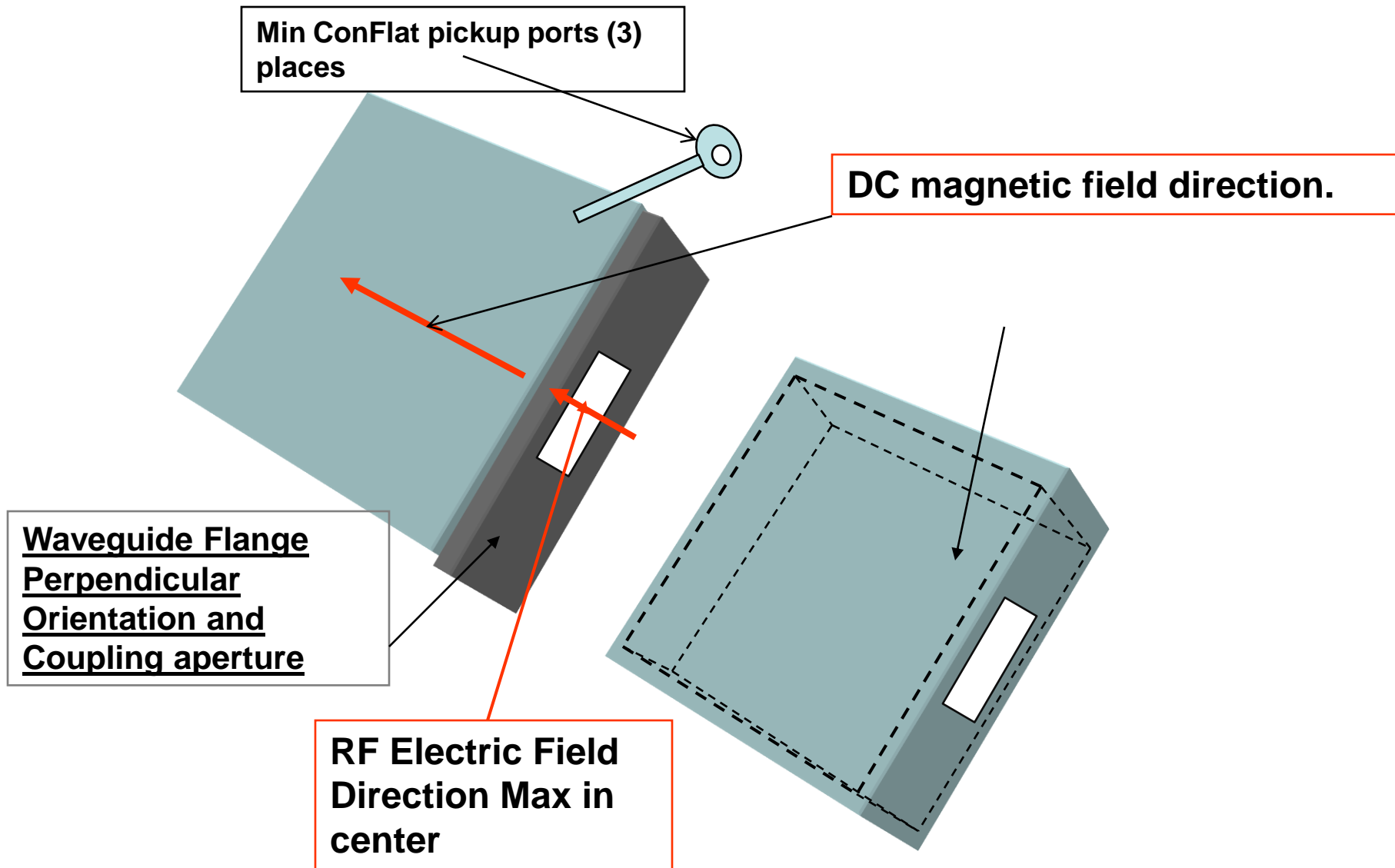
07/07/09

Al Moretti

Outline :

- **Description of the Box cavity Concept.**
- **Box Cavity Summary Plans.**
- **HFSS Models of orthogonal and Parallel cavities.**
- **Pictures of Box cavity machined parts.**
- **Peak electric Field contours.**
- **New and different RF Cavity Commissioning Proposal.**
- **Specifications.**
- **Qo, Resonant Impedance, Power requirements, peak surface fields.**
- **Status.**
- **Summary.**

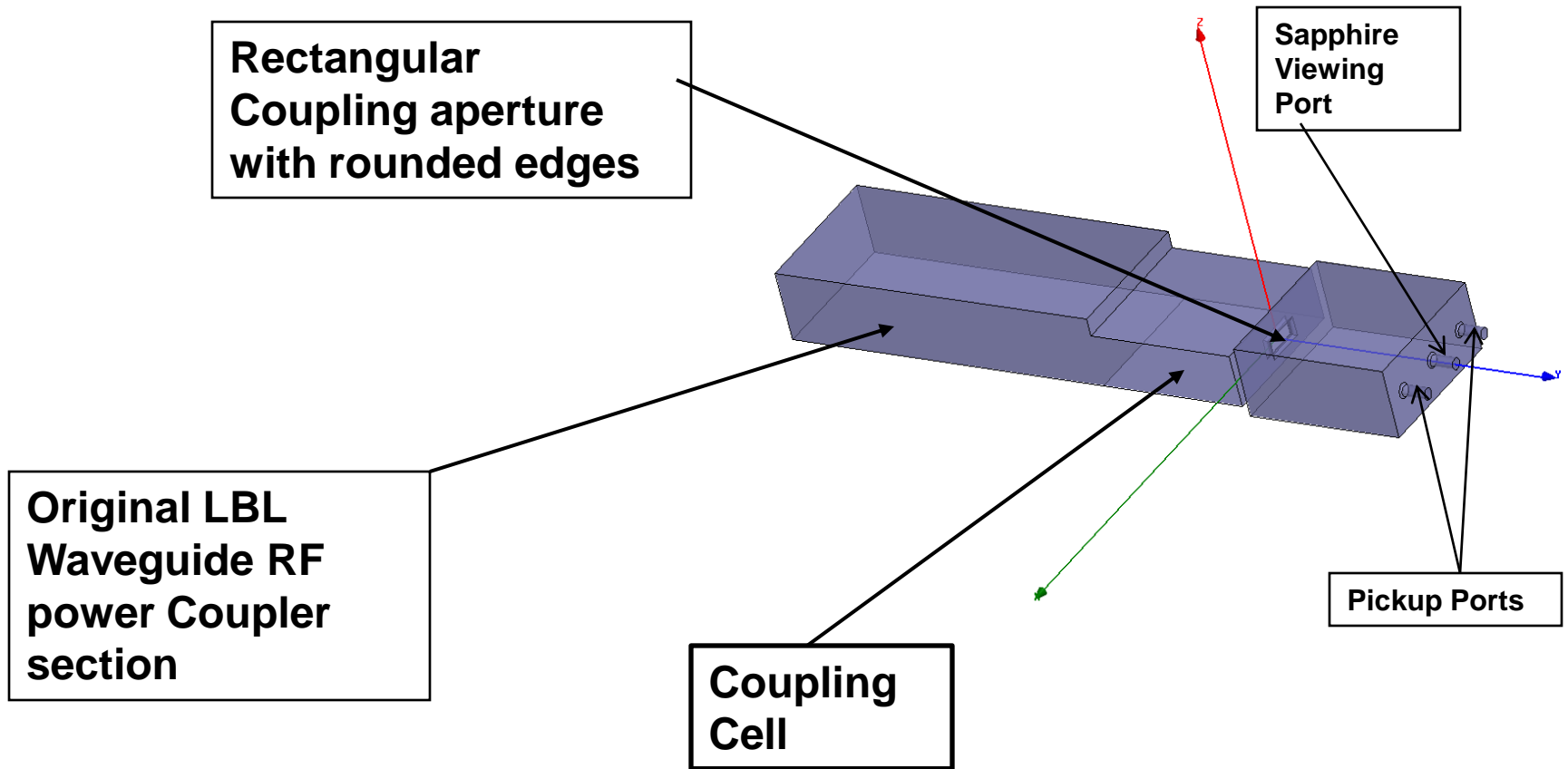
Simplified View of Box Cavity for Field Orientation Studies



Box Cavity Summary Details:

- Rectangular box cavity is made of 101 OFE copper plates. Interior Parts and the aperture will be machined into parts with 32 μ inch finish. Then the sides will be screwed and foil hydrogen brazed together, First Braze Cycle; 2 cross Field cavities are being made and one Parallel cavity is being designed. The HFSS simulation coupling aperture will be machined in one of the end walls and the SS waveguide flange will be brazed in place as well as the pickup coupling SS tubes. The cavity and setup are being designed for 0 to 15 Degree rotation.
- This will come back to Fermilab and be finish machined for foil brazing of top and bottom plates; Water cooling channels will have been gun drilled into plates . Top and bottom plates we be electro polished. If required Coupling aperture will be trimmed after a RF cold test to determine Fo, Qo and near match coupling.
- Top and bottom plates; this then will be sealed and shipped back to Fermilab, Second Braze Cycle
- Another cold RF test will be made to determine Fo, Qo and coupling. Coupling aperture will be trimmed for near match condition if required.
- The rotating support fixture (upto 15 degrees) will be attached onto the current support frame.
- Vacuum system, drive waveguides, 2 RF cavity pick-ups and sapphire viewing window will be attached; after calibration testing will begin at 90 Degrees.

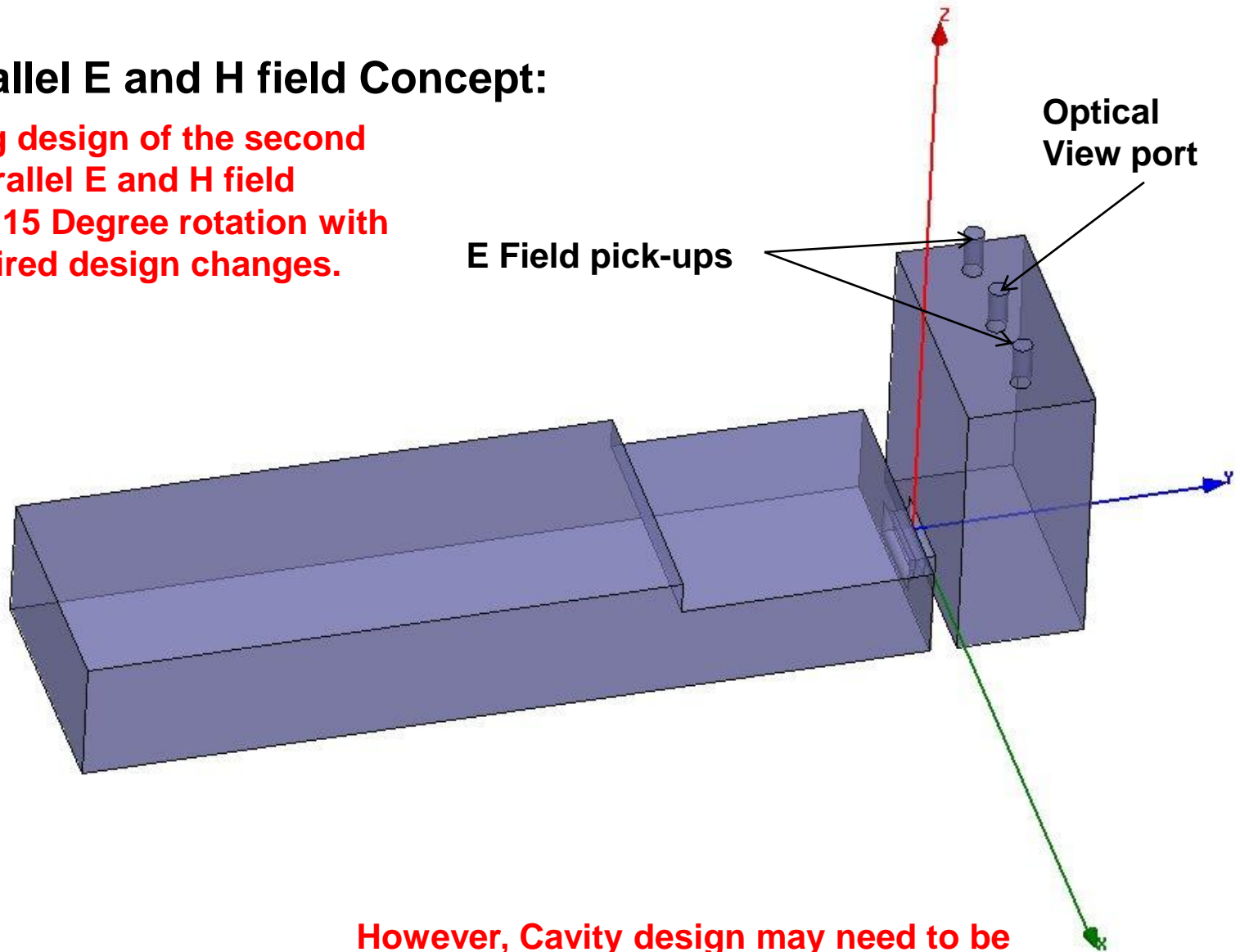
Orthogonal E and H Cavity Coupled to the Waveguide



HFSS Model RF cavity and WG coupler

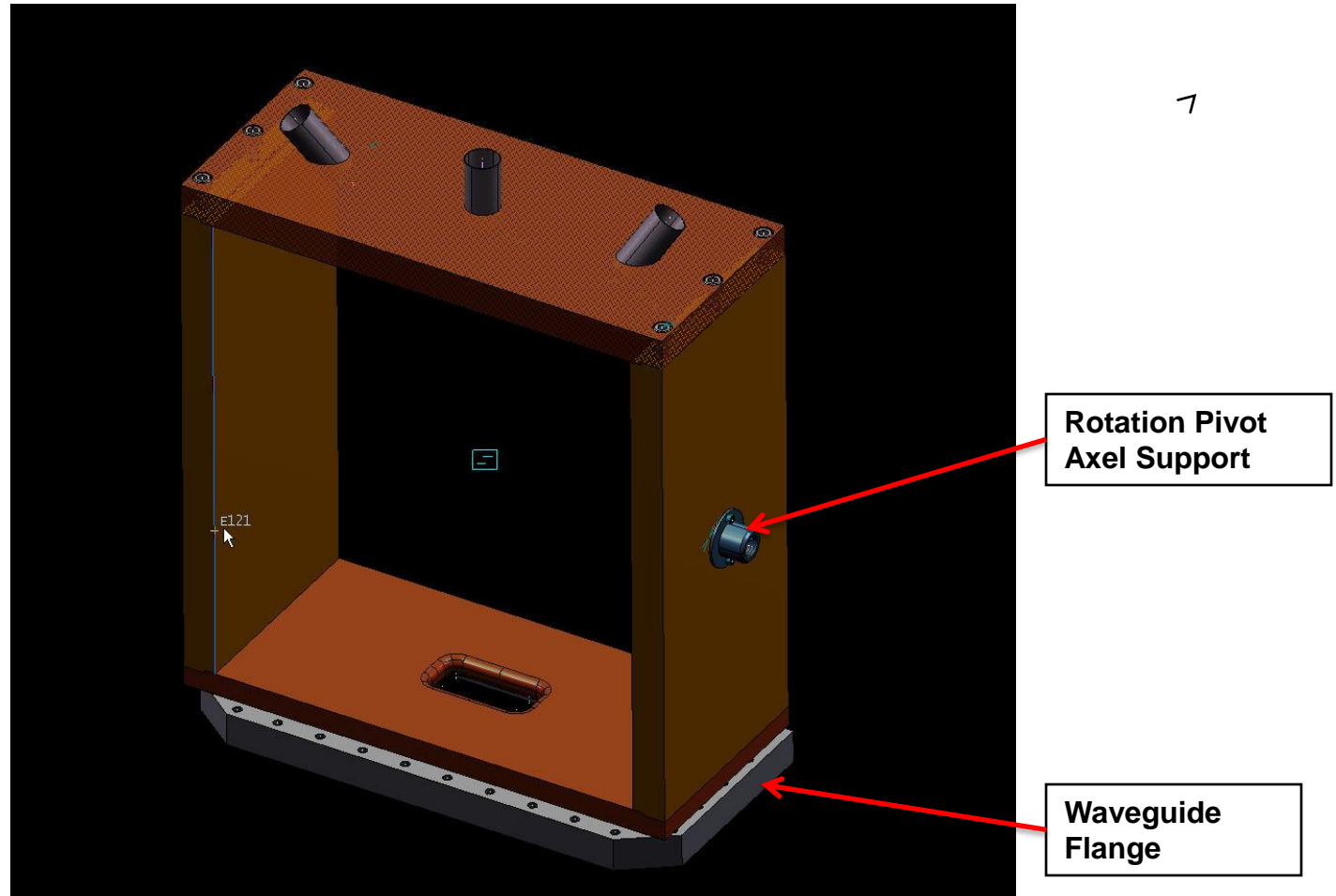
Parallel E and H field Concept:

Beginning design of the second of the parallel E and H field cavity for 15 Degree rotation with little required design changes.

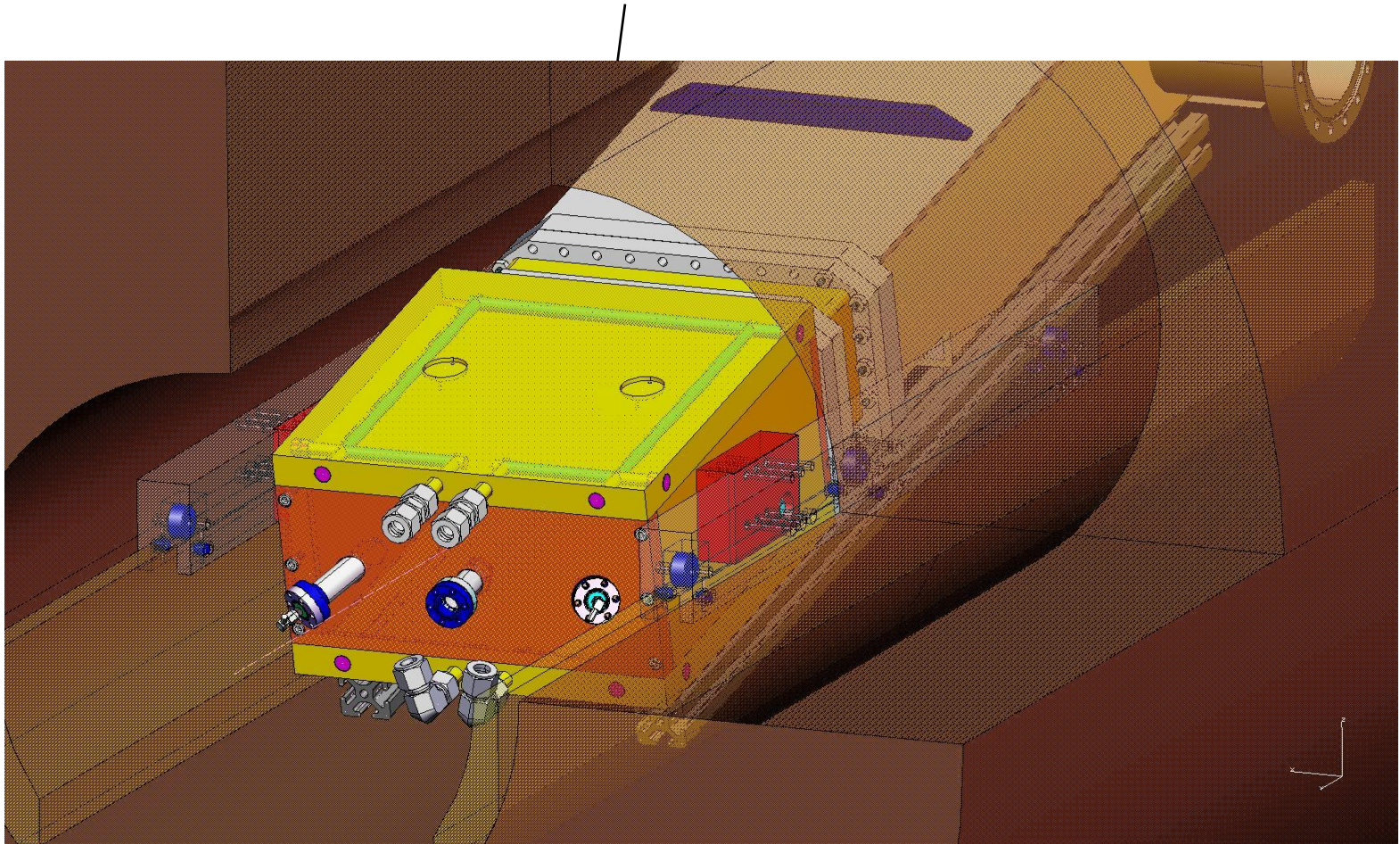


However, Cavity design may need to be Change to be able to rotate upto 15 Degrees.

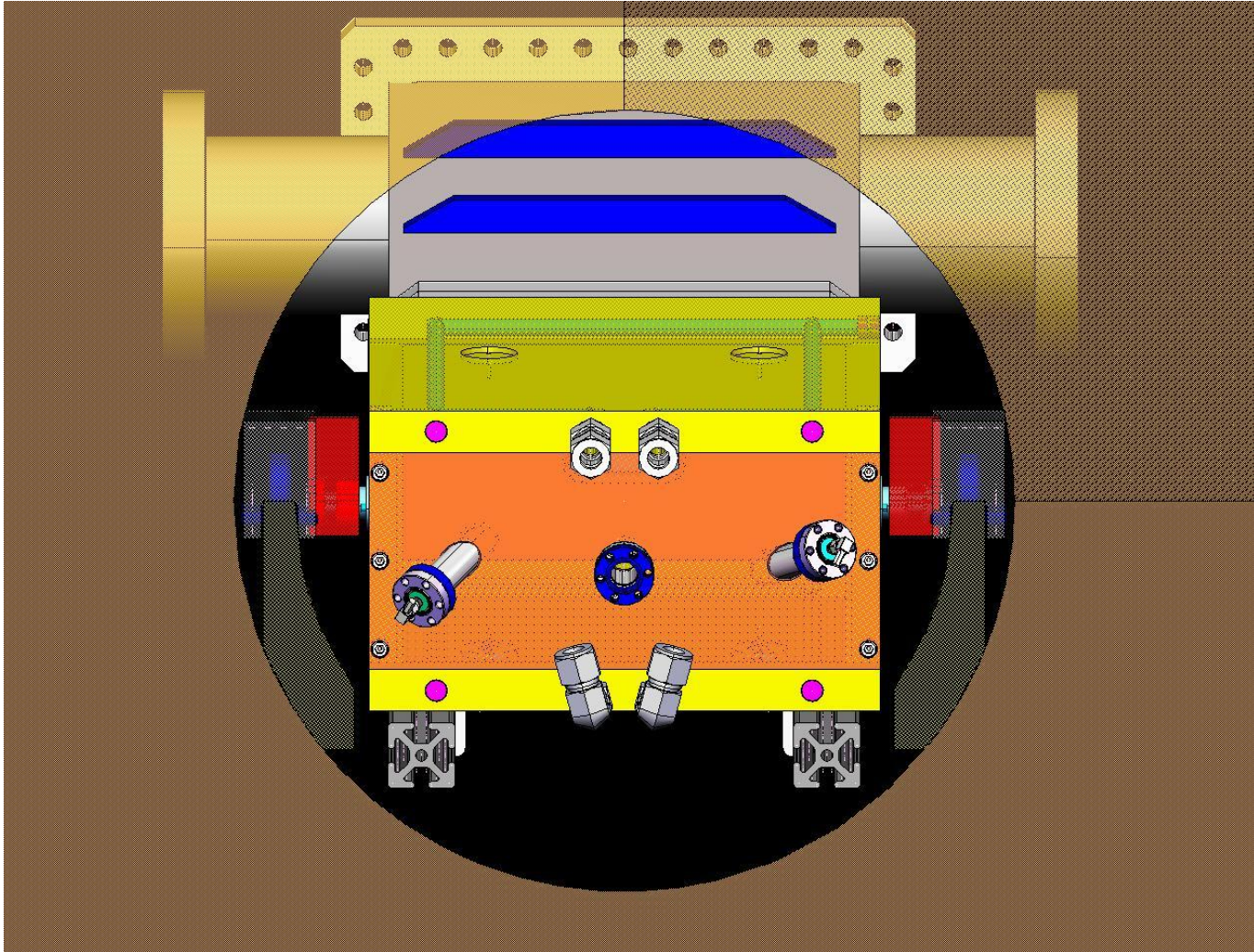
First Braze Cycle Box Frame



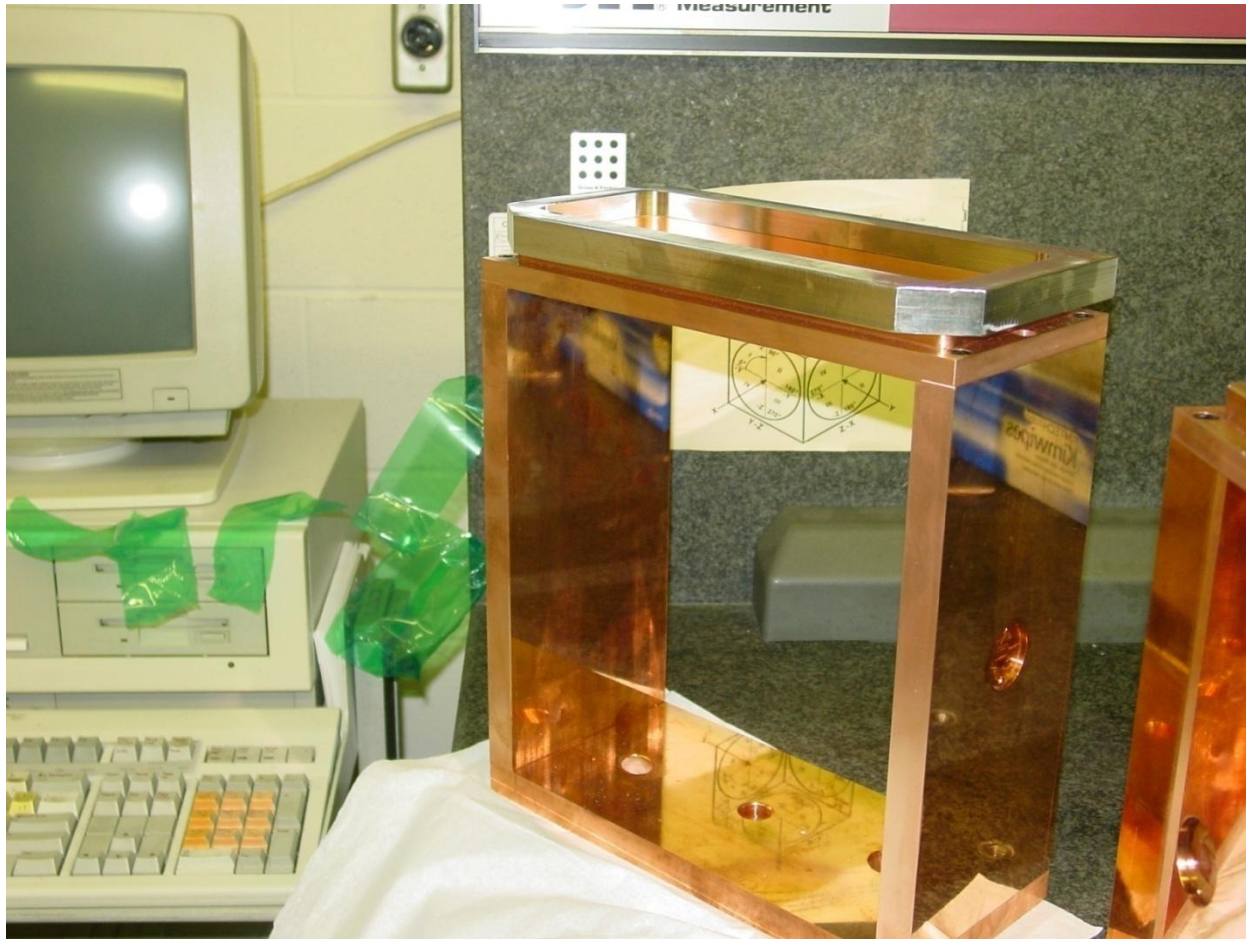
Box Cavity Attached to Waveguide Showing Water fittings and Pickups.



End View of The cavity in the Magnet



Box cavity Frame Setup for Dimensional measurement with SS WG Flange sitting on top.



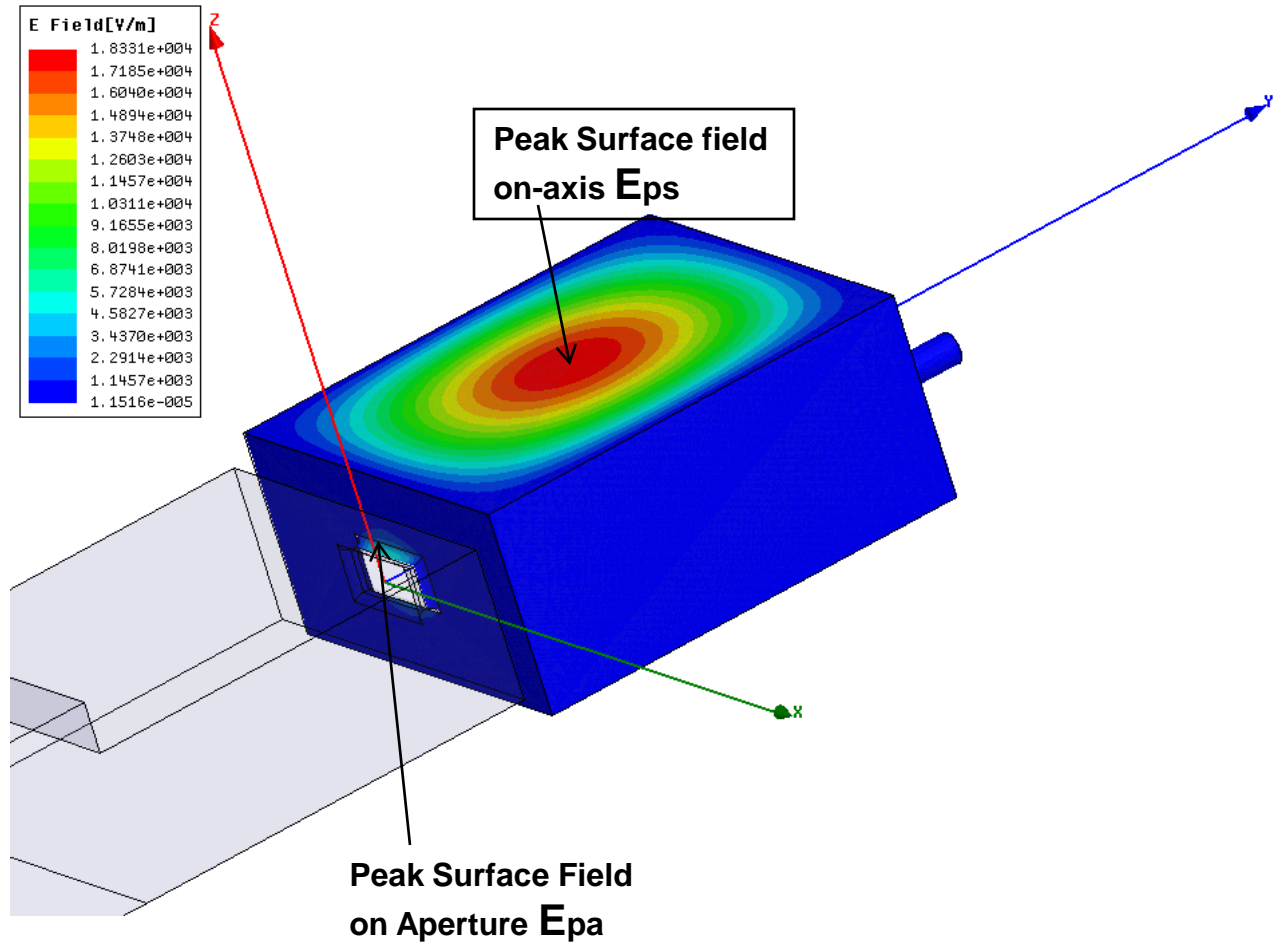
Picture of the same on Its side Showing view of coupling Aperture and pickup Ports



Orthogonal Cavity Electric Field Simulation

Note 1:
Ratio $E_{ps} / E_{pa} = 3.5$
for orthogonal case.

Note 2:
Ratio $E_{ps} / E_{pa} = 2$
for parallel case.



Specifications

The following are some of the specs for the square cavity:

Tolerance of parts = ± 0.005 " *(Parts were machined to +/- .0015 inches)*

Inside finish = 30 u inches

Average power = 5 kW with half the power dissipated equally on the Top and bottom plates the remainder almost equally on the 4 sides.

Pick-up ports: Three min-ConFlat vacuum feed-thru ports in the side opposite the coupling aperture, 2 with field pick-up loops and one with a Sapphire vacuum viewing window on a mini Con Flat flange.

Temperature: Max. temperature on inside surface of the un-cooled coupler aperture is $+37.2$ ° C at 5 kW with room temperature water circulating in the cooling tubes. The other max temperatures are at center of top and bottom plates is 38.1 ° C and 43.1 ° C on the long side plate.

Rotation Angle: $90 + \Delta 12$ Degrees, need to lower the center of cavity vertically 3.8 cm to achieve 15 Degrees.

Schedule and Cost estimate

Schedule

Schedule Comments

➤ Detailed drawings completed	-----	1 week	
➤ Procurement of materials Cu plates	-----	2 weeks	
➤ Machining parts for first braze cycl & Clean	-----	3 weeks:	At the machine shop, this week.
➤ First hydrogen braze cycle	-----	<u>1 weeks</u>	<u>To start July 7, 2009*</u>
➤ First RF “cold” measurement	-----	1 week	
➤ Machine parts second braze cycle & clean	-----	1 week	
➤ Second braze cycle	-----	1 weeks	
➤ Cold test and attach rotation structure	-----	2 week	
➤ Installation in magnet with vacuum and RF	-----	1 week	
		Total 13 weeks with high priority!	

➤ Material copper plate	-----	\$2000	
➤ 2 braze cycle	-----	4000	
➤ Machining of parts	-----	10000	
➤ Miscellaneous material and parts	-----	4000	
		Total = \$ 20,000 x 2 = \$40,000	

Calculated Parameters of the cavity and cavity dimensions

HFSS normalizes all parameters to 1 W of input power to the waveguide coupler and solves for the frequency, gradient, coupling factor, Q_0 (in cavity mode) etc.

1W produces a gradient of 25 kV/m by scaling:

25 MV/m would take 1 MW ideal.

The Impedance across the center of the cavity is

$$Imp = 9.5 \text{ M}\Omega.$$

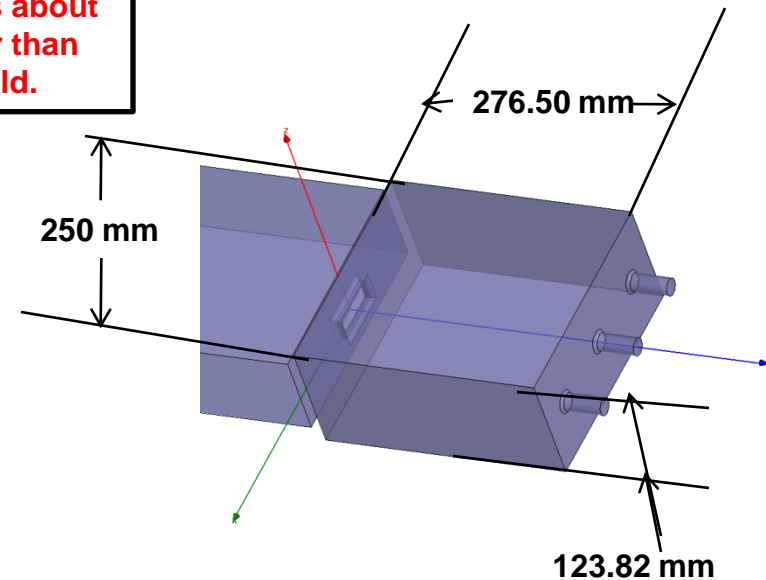
This is the resistance across the center of the cavity given by

$$Imp = (\text{gap Voltage})^2 / 1 \text{ W}.$$

This uses the peak voltage and is in agreement with SuperFish and most published accelerator designs.

$$Q_0 = 27,400.$$

Aperture Fields about a factor 4 lower than central max. field.



Status

- The machining of the parts for 2 orthogonal box have been completed. Parts are now being cleaned and assembled for shipment to brazing facility in Indiana. Shipping boxes have been fabricated and packing is in preparation. Jim Wilson will be present for all the brazing setup, brazing, leak checking and packing for return shipment.
- Began looking at the design of the parallel box cavity and its rotation possibility without major design changes other than the position and size of the coupling aperture. This cavity configuration only allows a peak Electric field reduce of about 2 for Eps/ Epa. *We need to decide if this is OK to proceed with fabrication.*
- Design of the supporting and rotating hardware is about 90 % complete. Need to design the waveguide transition pieces for the rotation angle or angles. Looking at straight pieces with proper angled CPR975 flanges.
- The fabrication is on schedule **with high priority** for the cavity to be operational in 12 to 13 weeks.

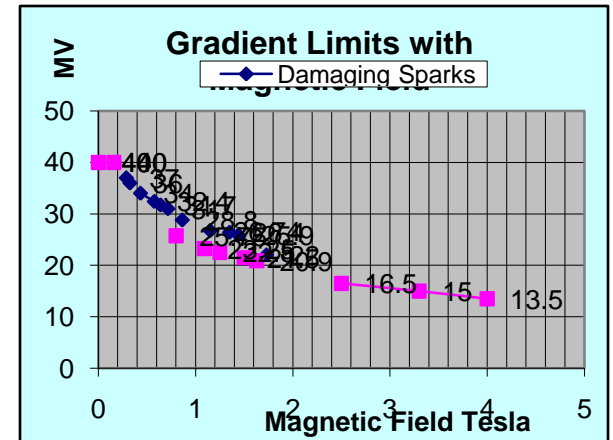
New and Different RF Cavity Commissioning proposal

I would like to RF commission either the LBL cavity or the Box cavity or both starting with the 3 T high magnet field breakdown limit. Using the magnetic breakdown curve as our guide, RF commission say to 10 to 15 % above the curve, 16.5 to 17.25 MV/m without the magnetic field. After this turn-on the magnetic to 3 T and RF commission the cavity with the magnetic field to its limit.

Reduce the magnetic field to say 2 T and rf commission again 10 to 15 % above the 2.75 T curve; increase the magnetic field to 2.75 T and RF commission with field upto its limit. This should be repeated until with trace out the whole curve down to say 0.25 T. In the past, we took the data by Increasing magnetic field in steps of 0.25 T upto 3 T. However in the past, we RF commissioned to 36 MV/m before RF commissioning with the magnetic field, starting out at 0.25 T. In this case, the reason we do not want to go to zero magnetic field is the charging and discharging time of the magnet are to long, hours.

I especially want to do this for the orthogonal cavity. I am of the opinion now, that it does no good to RF commission the cavity or cavities without the magnetic to very high gradient. All this does create pits that interfere with the magnetic field commissioning results.

If other agree at this point, we can not do very much without the 5 T magnet being operational. We could, however, RF commission the cavity at this low valve of 16.5 to 17.25 MV/m for the length of time it takes for the refrigerator to be operational. *We have noted large improvements in breakdown limit of vacuum cavity in our linac with very very long running times.*



Summary

- The orthogonal cavities should be operational the end of August to early September.
- The parallel cavity is in the early design stage. We need to know if a Ratio $E_{ps}/E_{pa} = 2$ for parallel case is OK to proceed with the design. Without a difficult Endfire design it may be impossible to do much better. I will continue to explore different aperture coupling design such as a dogbone design.
- We also need to discuss the priority of the next cavity to be tested. There are many options:
 1. The LBL Pillbox cavity with Be windows all facing in;
 2. The LBL Button cavity facing a Be curved window facing in,
 3. The orthogonal Box cavity,
 4. The parallel Box cavity,
 5. The Muons Inc. High pressure cavity with Beam.