LARP

High Luminosity LHC

HOM filter design for double quarter wave crab cavity

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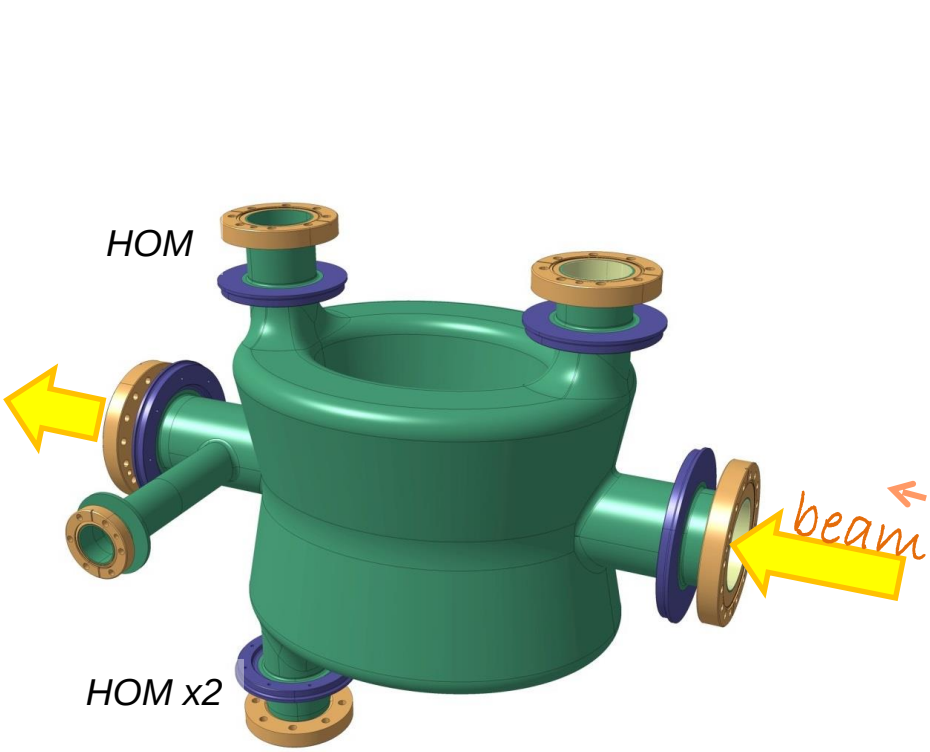
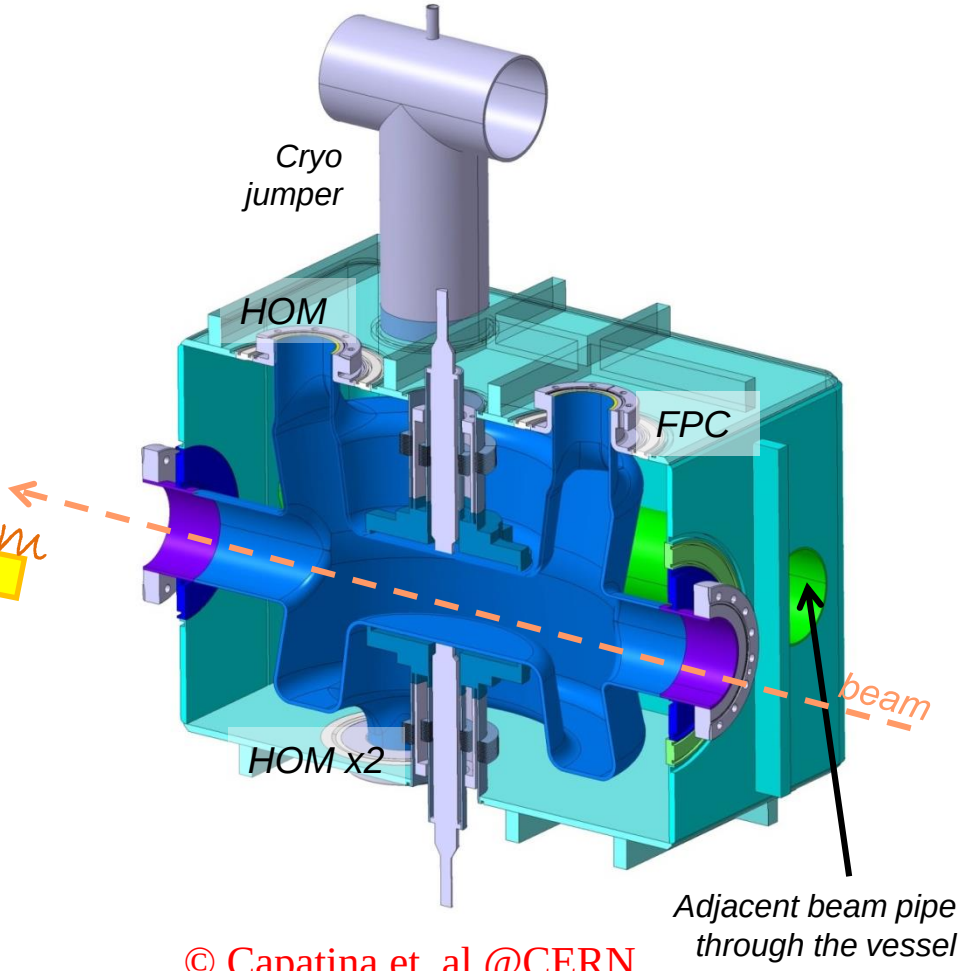
Outline

- SPS double quarter wave crab cavity
- Constraint in the HOM filter design
- Design of HOM filter
- Fundamental mode in HOM filter
- Shunt impedance
- HOM power estimation

SPS double quarter wave





Constraint in the HOM filter design

A liquid helium vessel for the HOM filter was not shown here

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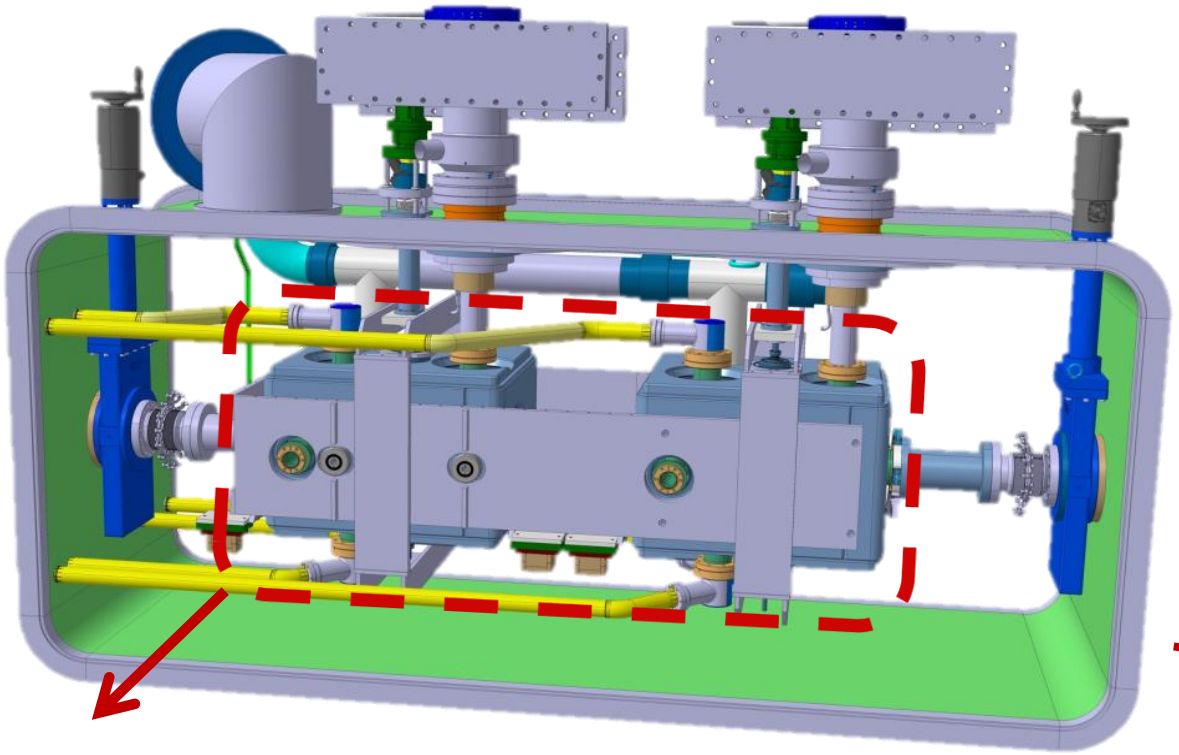
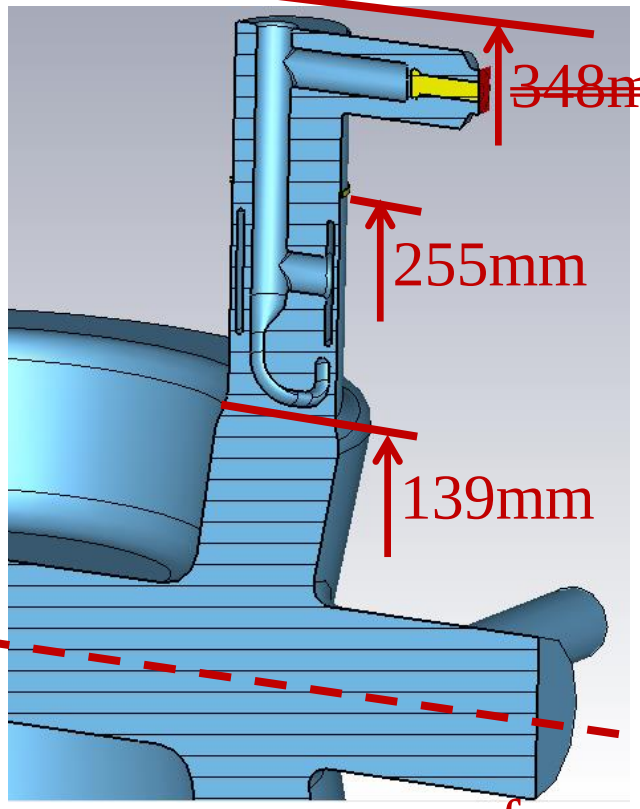
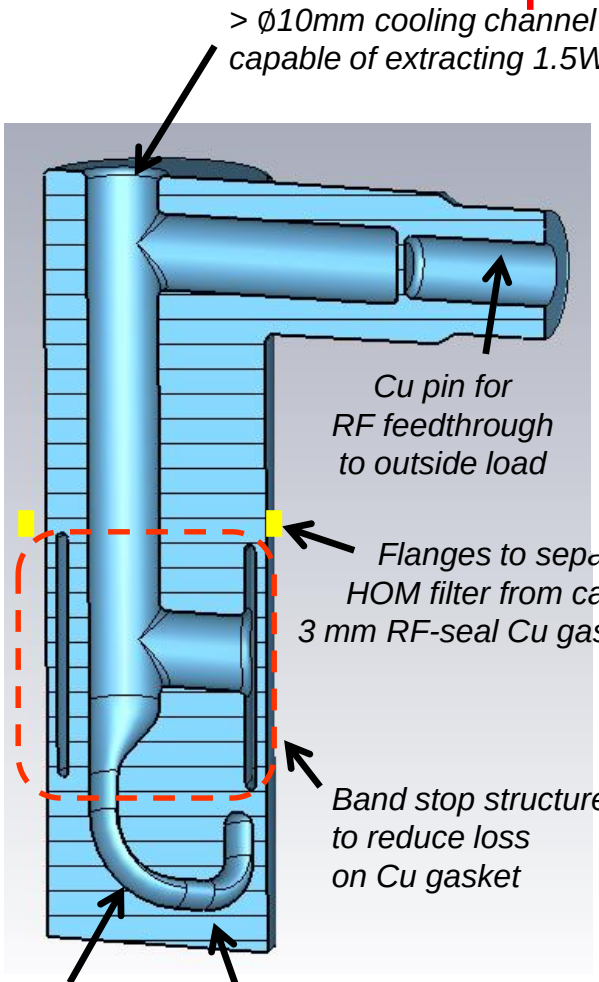


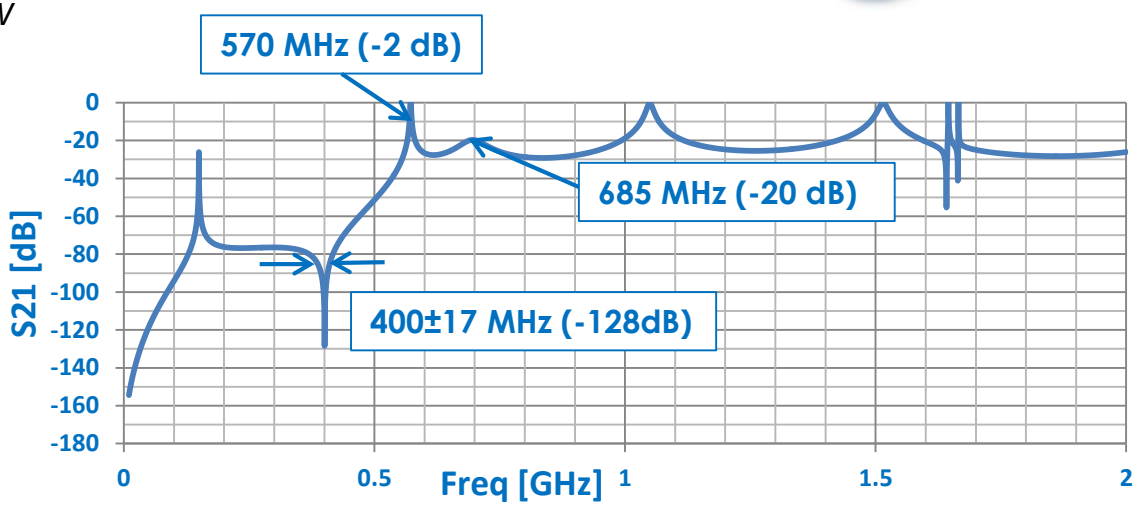
Magnetic & thermal shielding



reference

L-shape filter - SPS



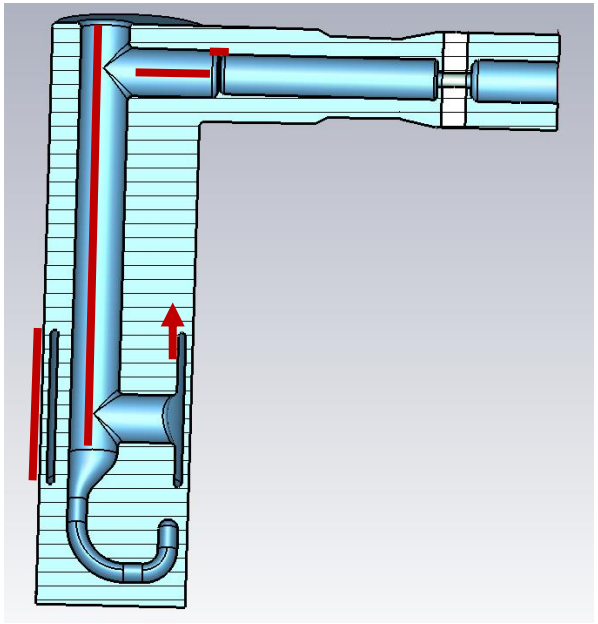


- L shape to meet the space constraint.
- Band stop structure to reduce loss on Cu gasket.
- 34MHz rejection band at 400MHz.

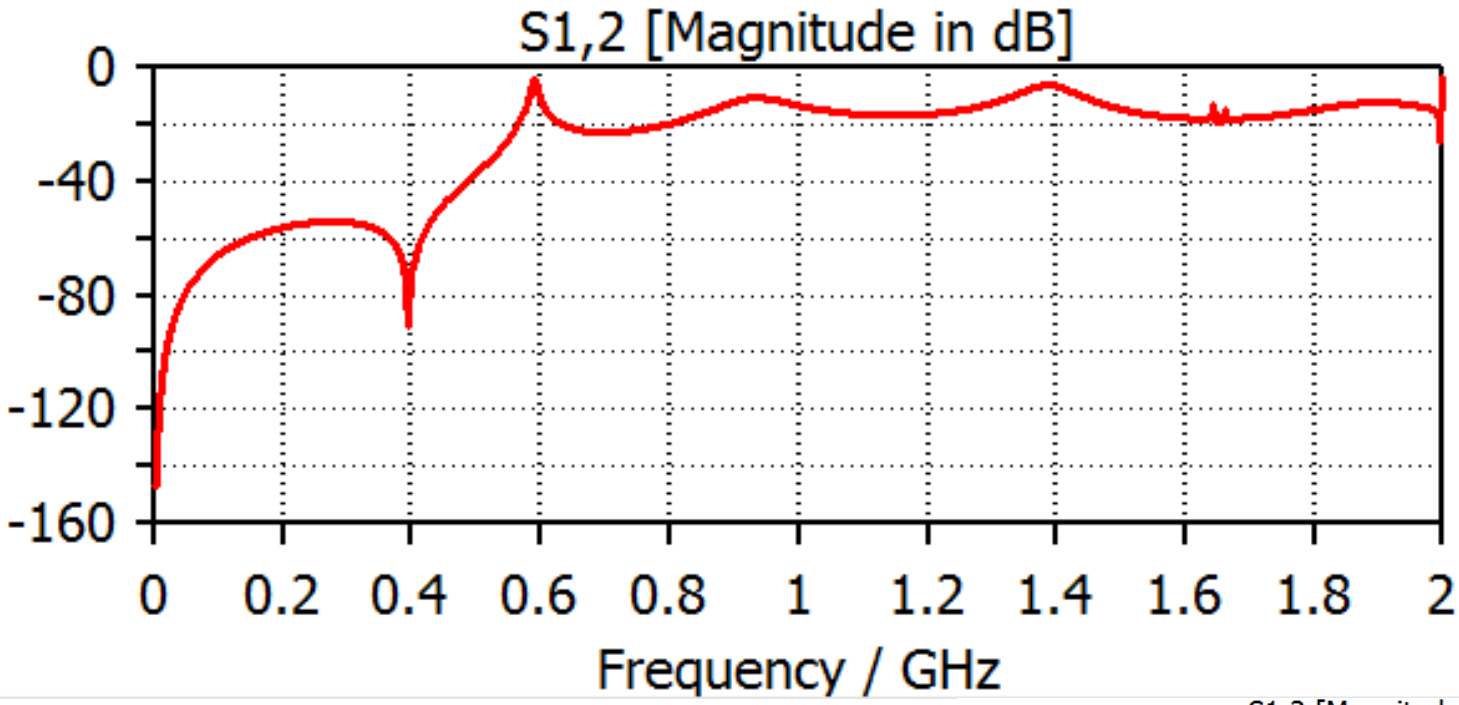
L-shape filter - Modification

Name	Value
Al_r	3
blending1point5	1.5
blending2	2
Cone1_L	5
Cone2_L	15
Conn_L	30
Conn_R	17
Cu_r	Conn_R/2.3+1
Gap1	3
Gap2	2
hookP1	20
hookP2	10
hookP3	20
hookP4	8
hookP5	10
hookP6	9
hookRa	8
hookRb	4
Rod1L	140
Rod1P	-9
Rod1R	10
Rod2P	-15
Rod2R	Rod1R
Rod3L	77
Rod3P	20
Rod3R	Rod1R
Rod4R	7.5
Tube1L	65
Tube1P	3.5

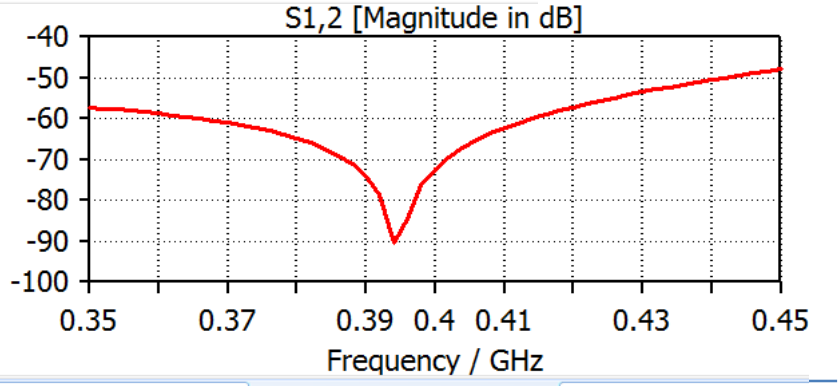
Al_r	= 3
blending1point5	= 1.5
blending2	= 2
Cone1_L	= 5
Cone2_L	= 15
Conn_L	= 30
Conn_R	= 17
Cu_r	= Conn_R/2.3+1
Gap1	= 3
Gap2	= 1
hookP1	= 20
hookP2	= 1+hookP6
hookP3	= 20
hookP4	= 8
hookP5	= 10
hookP6	= 9
hookRa	= 8
hookRb	= 4
Rod1L	= 180
Rod1P	= -9
Rod1R	= 10
Rod2P	= -15
Rod2R	= Rod1R
Rod3L	= 47
Rod3P	= 20
Rod3R	= Rod1R
Rod4R	= 7.5
Tube1L	69
Tube1P	= -4



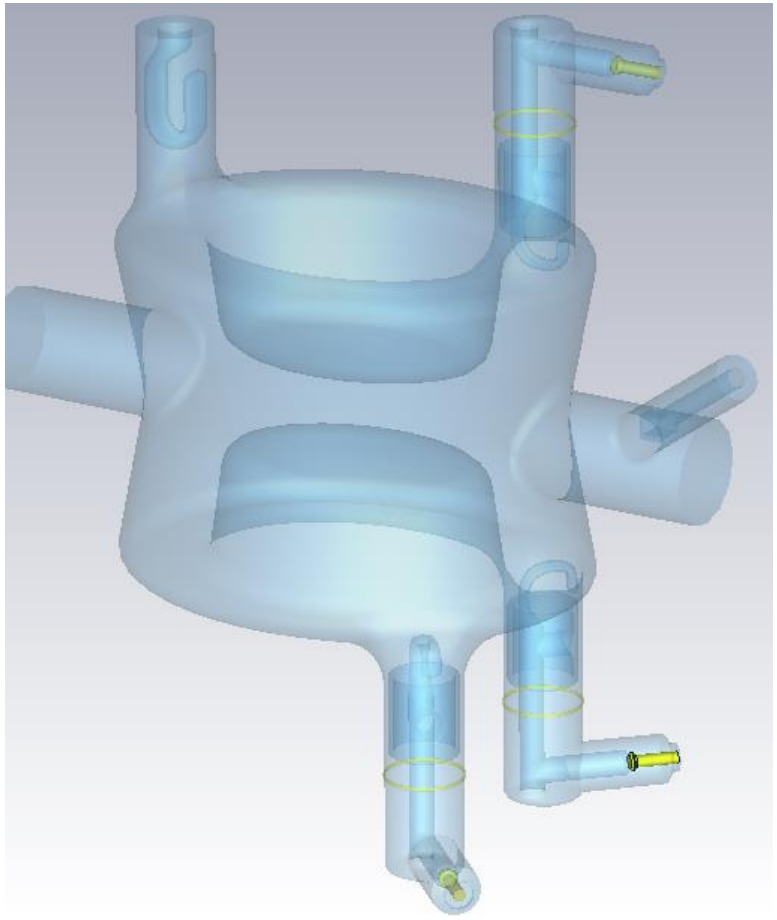
L-shape filter - Modified



Better coupling for 0.6~2GHz modes.
400 MHz rejection is optimized together with the cavity.

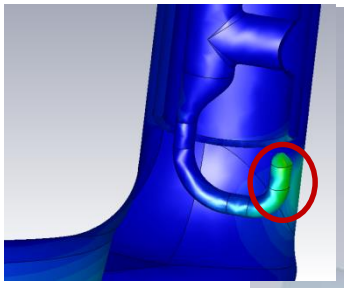


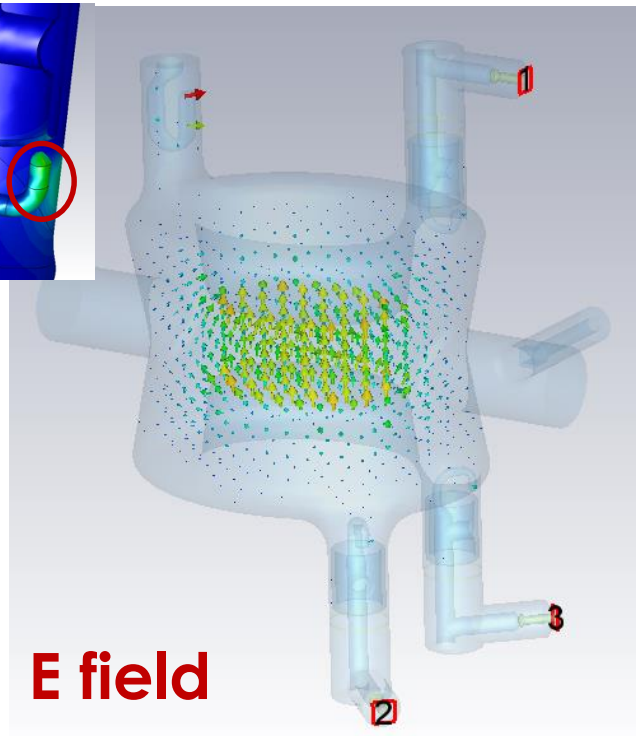
Filter integration



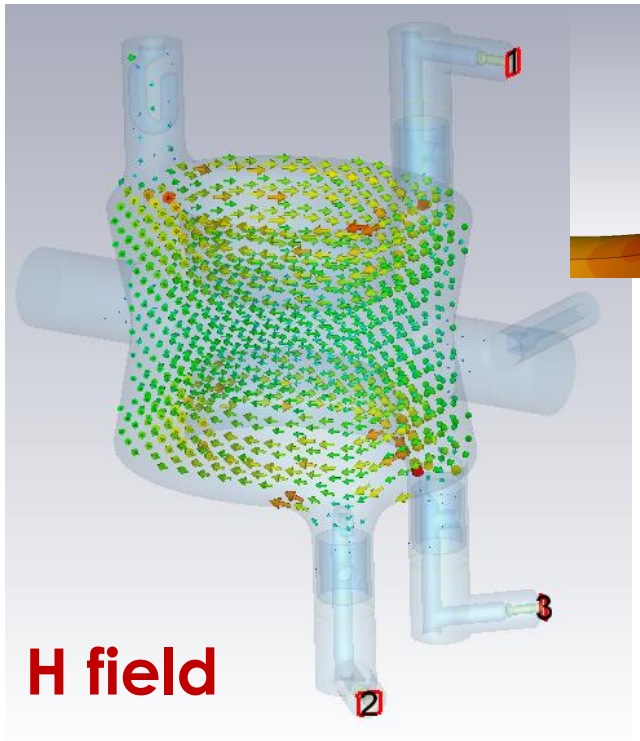
- 3 HOM filters per cavity, with two 60-degree away from the center to give ***clearance to the other beam pipe*** in horizontal kick scheme
- ***Symmetrical*** design to minimize multipolar components.
- 60 degree is chosen to provide more coupling to HOMs.
- ***Compact*** to fit into cryomodule.
- Longer RF cables can be easily attached to the L shape filter to ***reduce static heating***.

Filter at 400MHz - SPS

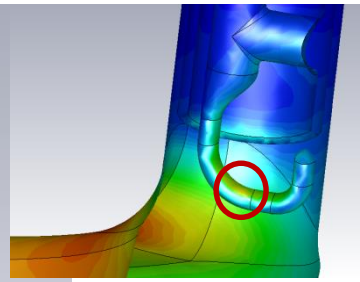




E field



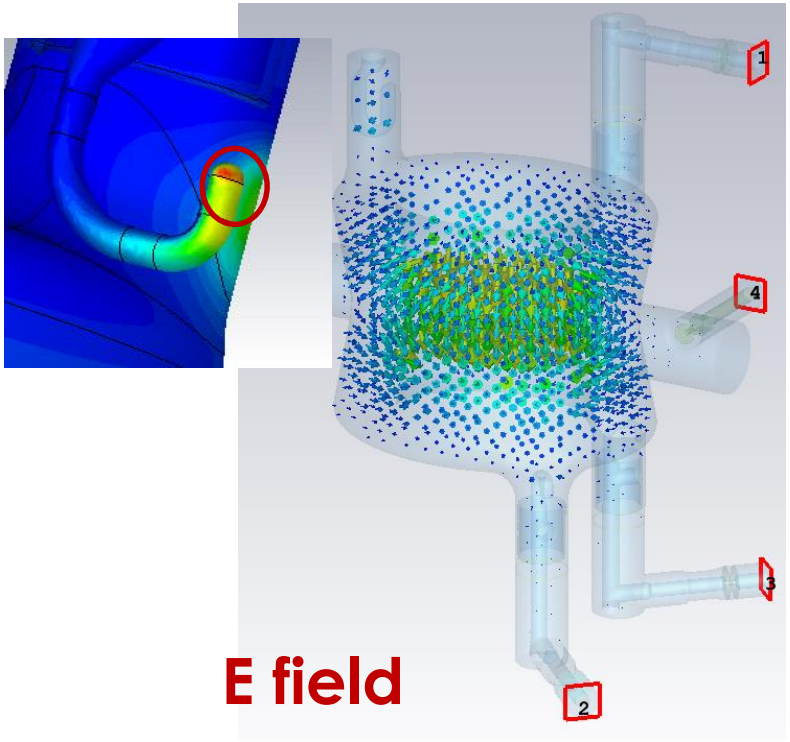
H field



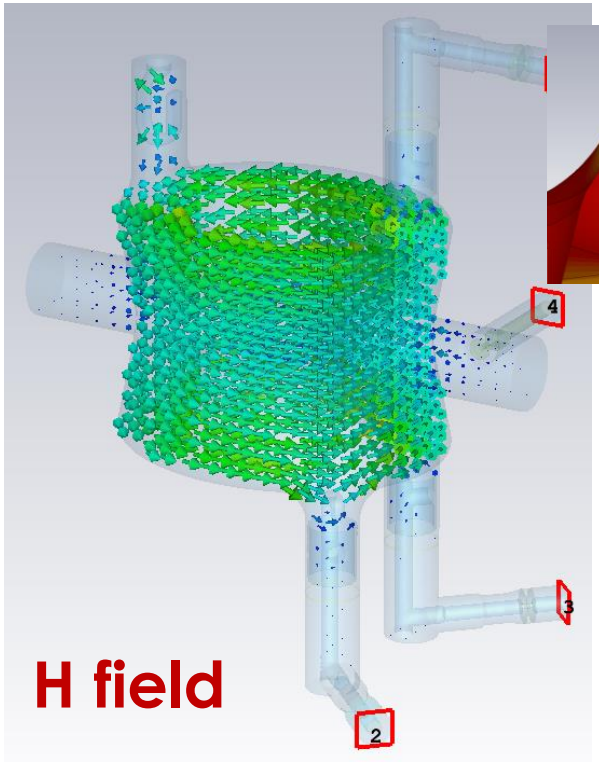
For 400MHz crabbing mode with V_t = 3.34MV:

- Peak E field on the hook: 19.3MV/m, on the cavity: 36.7MV/m.
- Peak H field on the hook: 61.3mT, on the cavity: 71.3mT.
- Coupling to 400MHz: 7.9×10^9, 1.1 W at each port to outside load.
- 30mW dynamic loss per filter for 20nΩ resistance.
- 7.8mW range RF loss on Cu gasket.
- 10.8 μW range RF loss on Cu pin.

Filter at 400MHz - modified



E field

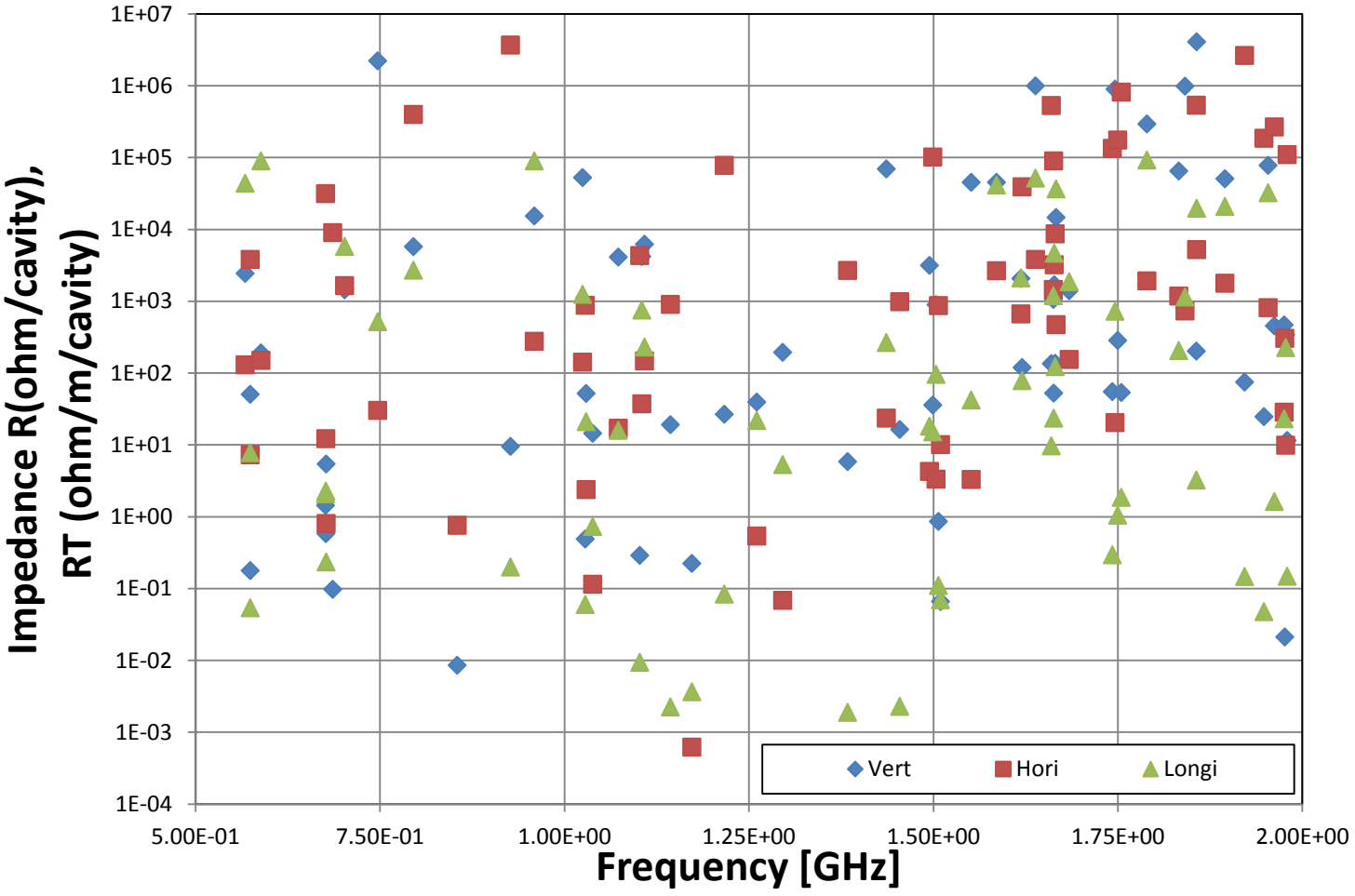


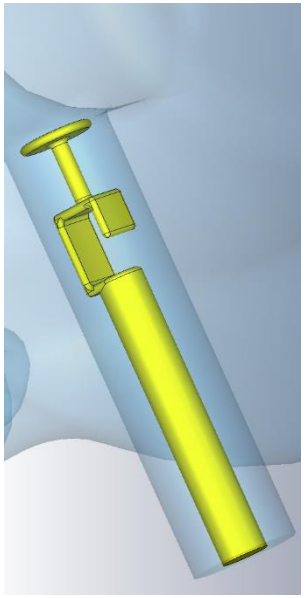
H field

For 400MHz crabbing mode with V_t = 3.34MV:

- Peak E field on the hook: 25.7MV/m, on the cavity: 37.1MV/m.
- Peak H field on the hook: 47.8mT, on the cavity: 70.4mT.
- Coupling to 400MHz: 2.2×10^{10}, 0.4 W at each port to outside load.
- 30mW dynamic loss per filter for 20nΩ resistance.
- Sub μW range RF loss on Cu gasket.
- Sub μW range RF loss on Cu pin.

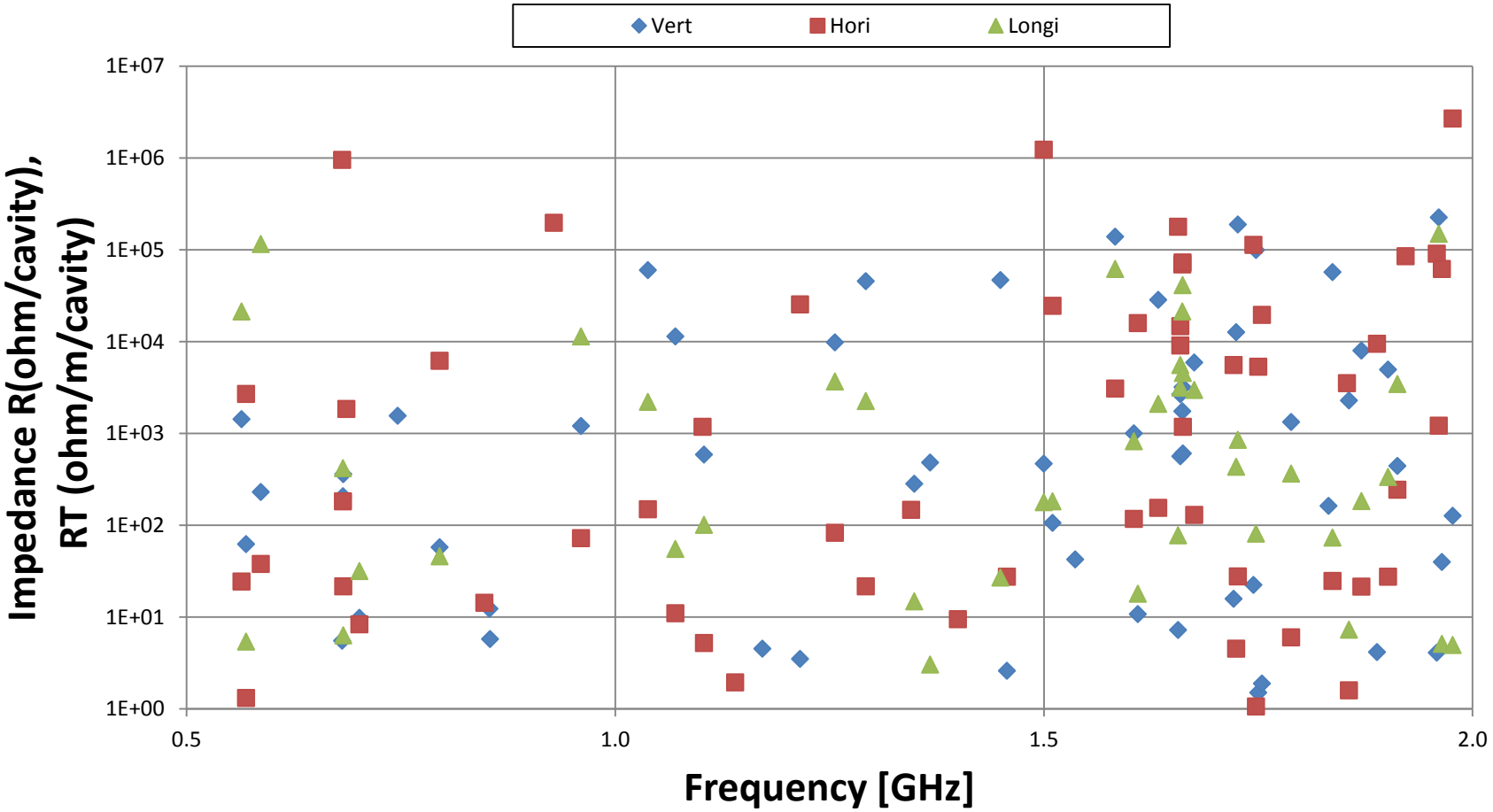
Shunt impedance - SPS





need the help from pickup port (for 1.75GHz)

Shunt impedance - Modified

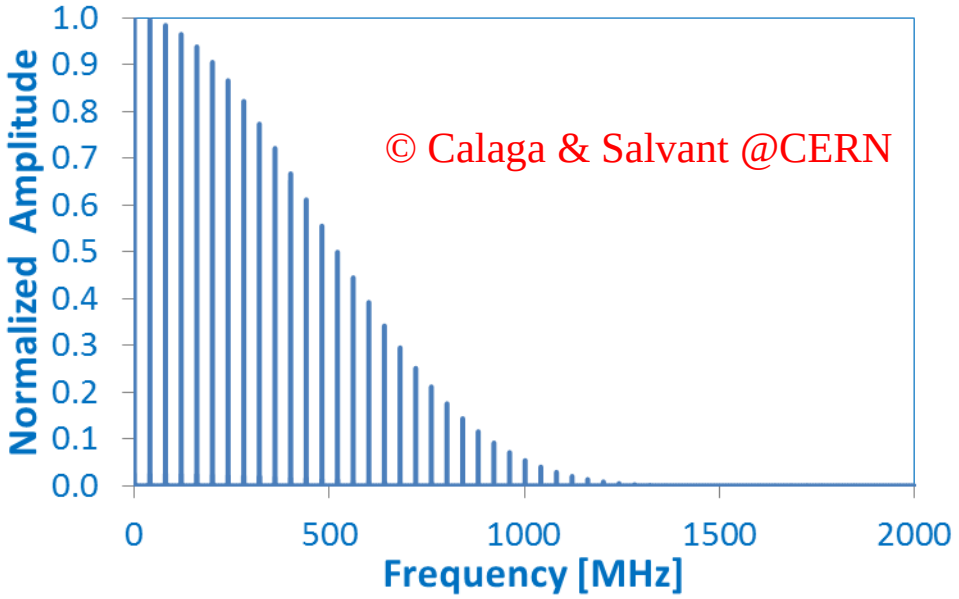


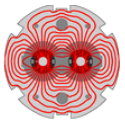
We still need the help from pickup port (for 1.5GHz), I suggest we put two ports, one dedicate to PU and the other one dedicate to HOM.

HOM power estimation - modified

	F (MHz)	564.1	586.4	681.4	701.6	960.1
	Mode Type	L	L	H	L	L
	Qext	1600	2630	6710	5	1170
Impedance	Longitudinal [Ω/cavity]	21300	115000		32	11400
	Horizontal [Ω/m/cavity]			339		
	Vertical [Ω/m/cavity]					
	HOM Power [Watt]	36.8	12.4	25.4	45.0	7.6
	Close to harmonic of 40.08MHz	14^{th}		17^{th}		24^{th}

- Based on 25nS beam spectrum
- Power of transverse modes estimated based on 5mm offsets.
- HOM power is about 132 Watts per cavity





Thank you!