1.3GHz WOW type crab cavity for ILC

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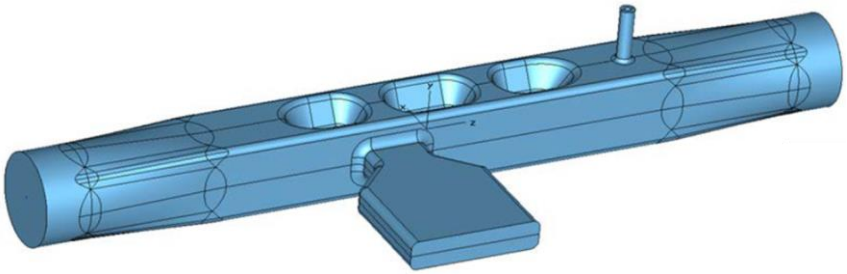
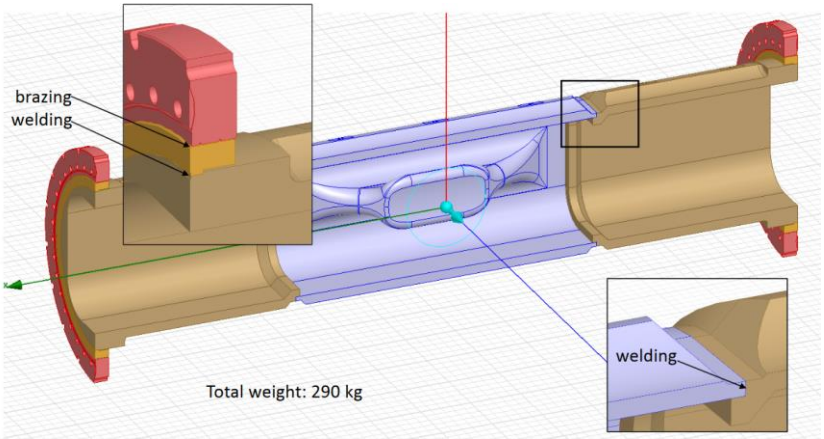
WOW type crab cavity

- Crab cavity with wide open waveguides (WOW) was proposed back in 2014 in HOMSC meeting by Fermi Lab colleagues (Quasi-waveguide Multicell Resonator: QMiR).
- CERN colleagues proposed WOW type crab cavity for LHC & FCC in 2015.
- EIC proposed to use WOW+RFD as a backup solution for 394MHz crab cavity.



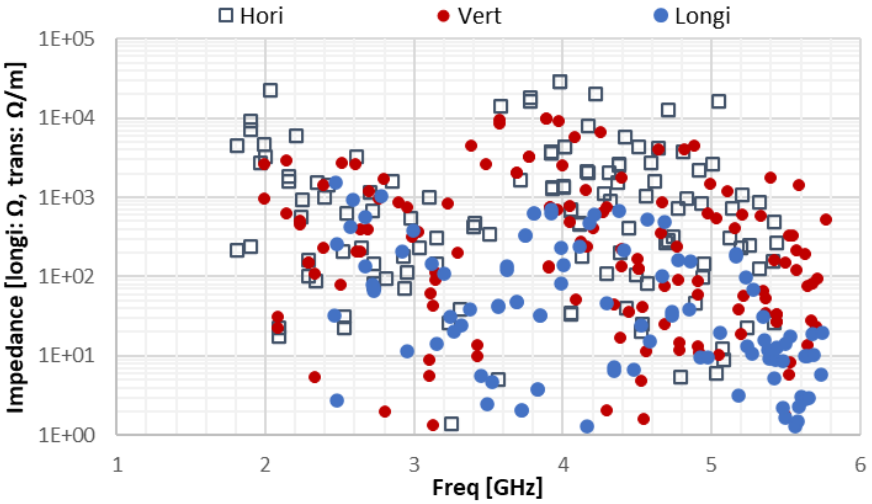


https://indico.fnal.gov/event/7942/contributions/104178/attachments/68128/81727/HOM_Free_Deflecting_Cavity.pdf
https://inspirehep.net/files/40359296b280f1cdd0a2b1cb94e33785

EIC WOW type

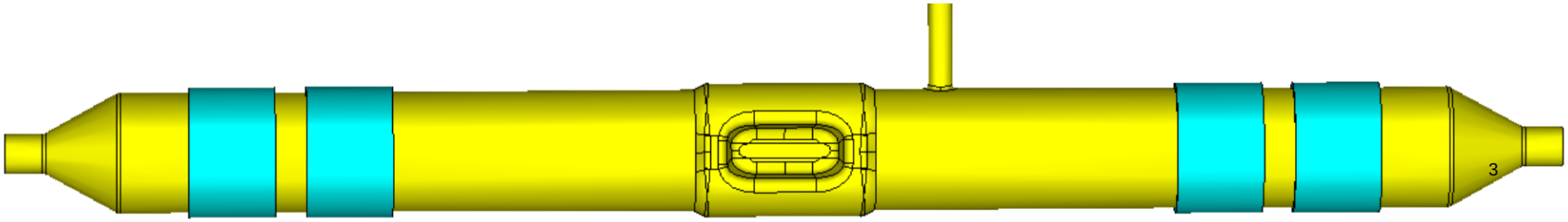
(Scaled to 1.3GHz)

- Two SiC absorbers on each side.
- 30.3mm gap & 94mm pipe.
- Vt: 1.27MV, Epk: 50.4MV/m, Bpk: 80.0mT. Can be improved.
- Max imped, longitudinal: 1.5e3Ω, transverse: 2.9e4Ω/m.
- Needs 6 cavities for 7.4MV.



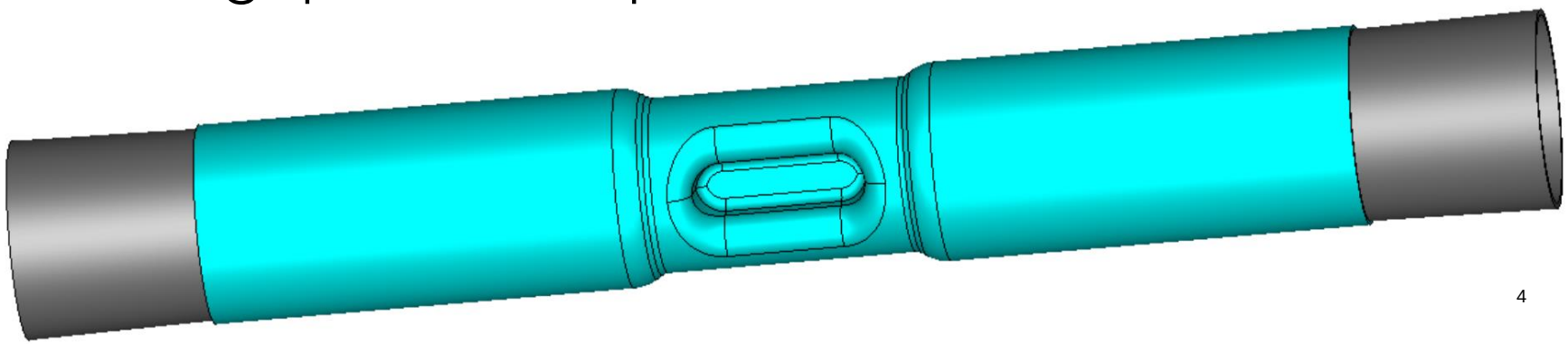
BNL/SLAC joint effort

- Adjacent cavities can share SiC absorbers.
- Total 4.74m, needs to be <3.8m.
- Further optimization to lower the peak fields (5 cavities instead of 6)



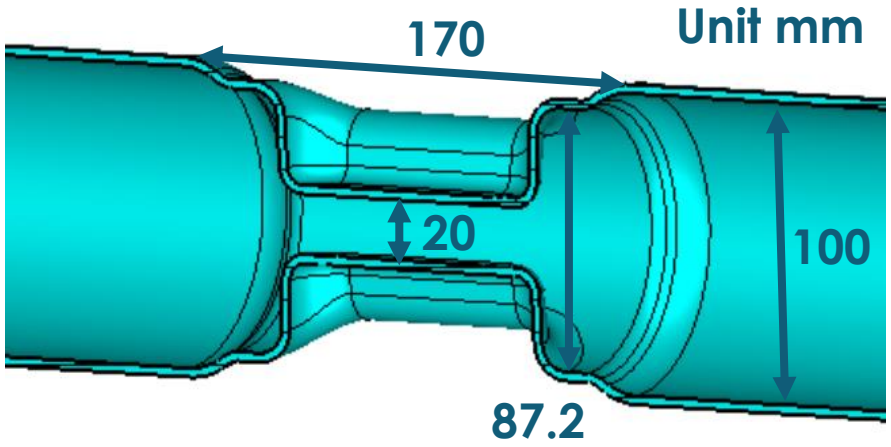
Design considerations

- RFD cavity shape, with WOW and beam line absorbers (BLA) on both sides.
- First transverse HOM at ~1.8GHz, first longitudinal HOM at ~2.3GHz.
- Choose 100mm ID WOW
  - with cutoff frequencies at 1.758GHz for TE_{11} and 2.297GHz for TM_{01}.
  - It is a good size for gate valve, no need for tapering.
  - it is also the beampipe size for EIC crab cavities.
- 20mm gap between poles.



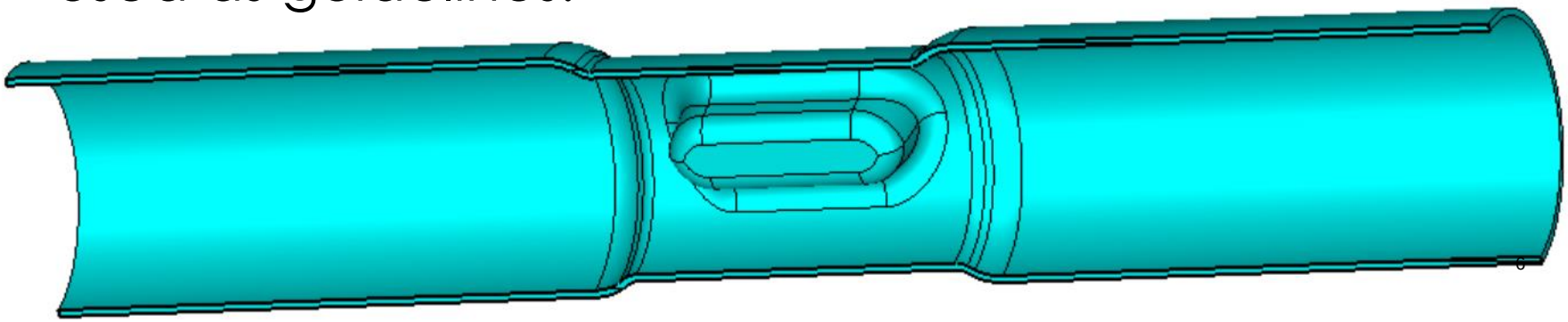
Cavity parameters

Property	Value
Operating frequency [GHz]	1.300
1st longitudinal HOM [GHz]	2.318
1st transverse HOM [GHz]	1.878
E_p/E_t with $E_t=V_t/(\lambda/2)$	3.37
B_p/E_t [mT/(MV/m)]	5.77
B_p/E_p [mT/(MV/m)]	1.71
G [Ω]	112.0
R/Q [Ω]	732.2
R_tR_s [Ω^2]	80470



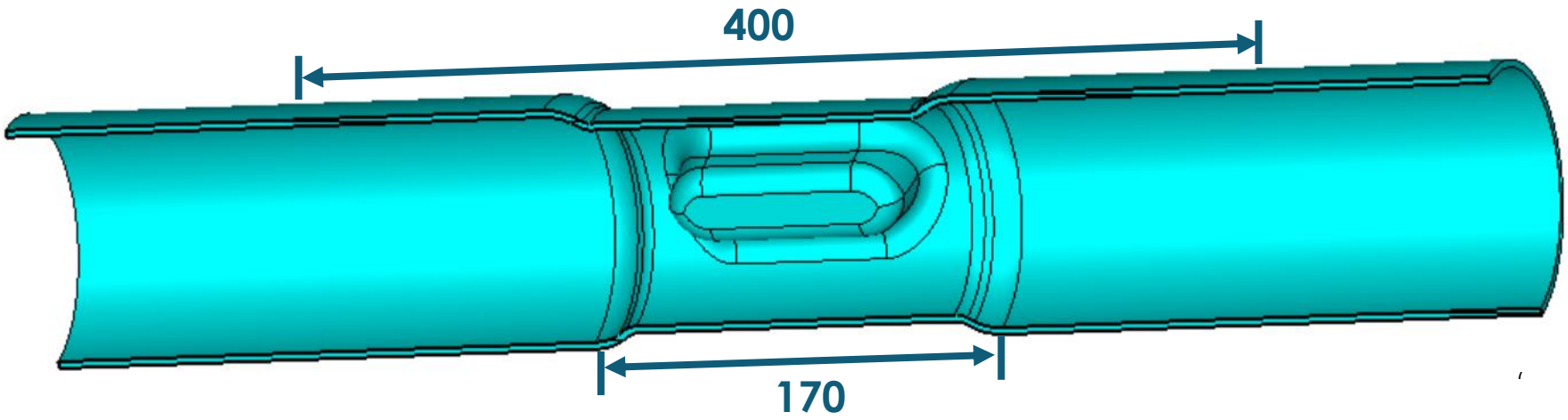
Peak fields

- Needs 1.845MV for 125GeV case and 7.4MV for 500GeV case.
- 1 cavity (per beamline) for 125GeV and 4 cavities for 500GeV, meaning 1.85MV per cavity, corresponding to 54.1MV/m E_{pk} and 92.6mT B_{pk}.
- If we use 2 cavities for 125GeV and 5 cavities for 500GeV, and 1.48MV per cavity, peak fields drop to 43.3MV/m E_{pk} and 74.1mT B_{pk}.
- For comparison, for EIC design 45MV/m and 80mT are used as guidelines.



Interfaces

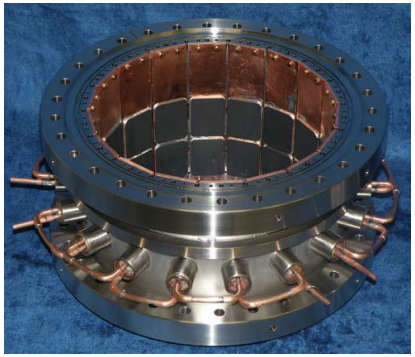
- All interfaces should be determined using 1.85MV per cavity (nominal) since it is more critical.
- Cavity helium vessel is placed at 8mT magnetic field under nominal voltage. Length of helium vessel can be as short as 170mm.
- Cu gasket is placed at 220A/m. Minimum cavity length (flange to flange) is 400mm.



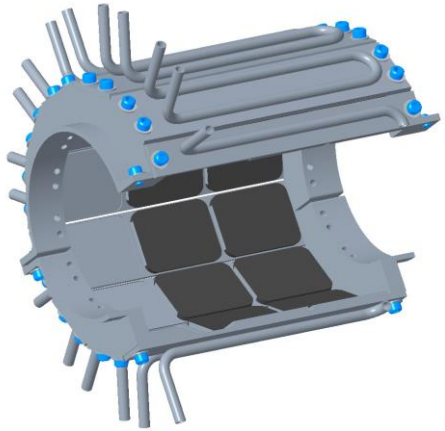
BLA

- Optimization of BLA is still on-going.
- Possible solutions include one BLA with tapered thicknesses, two BLAs with different thicknesses (uniform thickness in each), and BLA with ferrite tiles.
- At BNL, we have experiences on BLA with uniform thickness (for EIC) and BLA with ferrite tiles (for LEReC booster cavity).

Shrink-fit SiC (W. Xu)



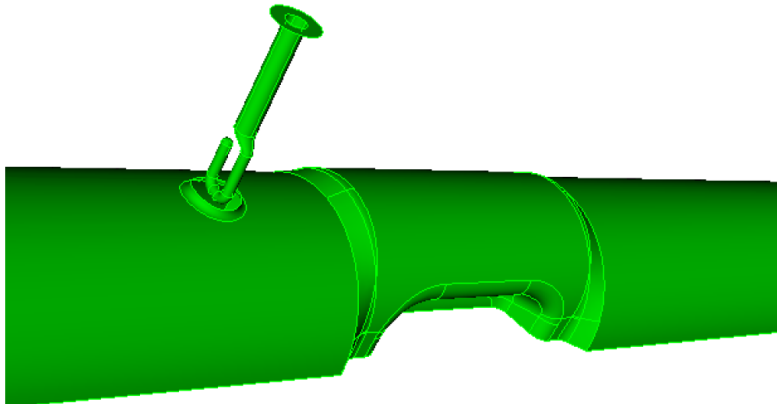
Tile SiC (T. Schultheiss, SBIR)

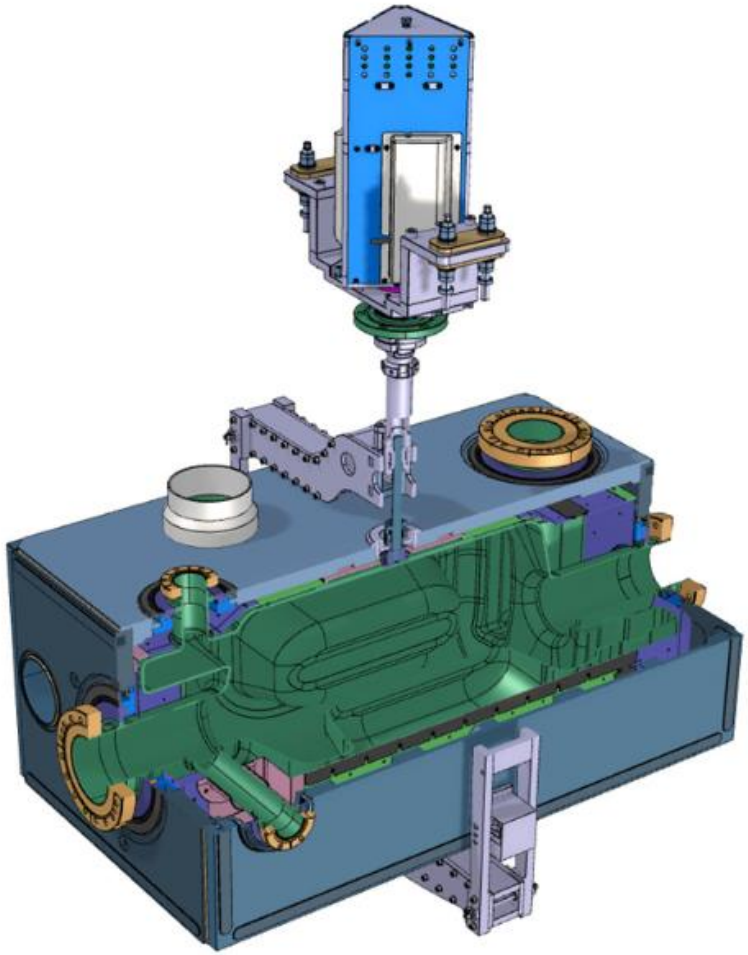


Tile ferrite (TT2-111R) for LEReC

FPC and tuner

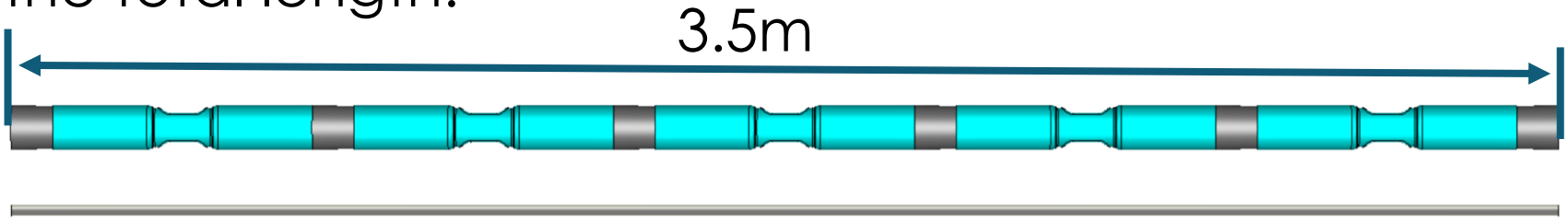
- FPC will be similar to the EIC WOW type, coaxial type hook coupler, vertically outside the helium vessel. For EIC WOW type, a 5e5 Q_{ext} can be achieved.
- Tuner will be similar to the LHC RFD cavity, with scissor jack tuner applying force symmetrically to the top and bottom (vertically) of the cavity.





Cavity string (estimation)

- Simple design with single cell cavities and BLAs between cavities.
- Total length 3.5m.
- Use 2 cavities for 125GeV first, depending on the operational experience, choose either 4 or 5 cavities for 500GeV.
- Reducing the beampipe diameter can further reduce the total length.



Gate valves, bellows and cryomodules not shown here, they will not occupy extra length though.

Summary

- WOW + RFD is a good candidate for ILC.
- Pros: Simple (robust) cavity design, with FPC/PU/BLA all outside the helium vessel, BLA can be inside/outside cryomodule. Cons: total length needs to be managed within 3.8m.
- Finished preliminary cavity design.
- Optimization on cavity/BLA is on-going.
- More effort on ancillaries (FPC/PU, RF window, amplifier, tuner etc) is needed.
- Could be a good joint effort.
- Inputs needed: gap dimension, peak E & H fields, impedance budget.