Various approaches to electromagnetic field simulations for RF cavities

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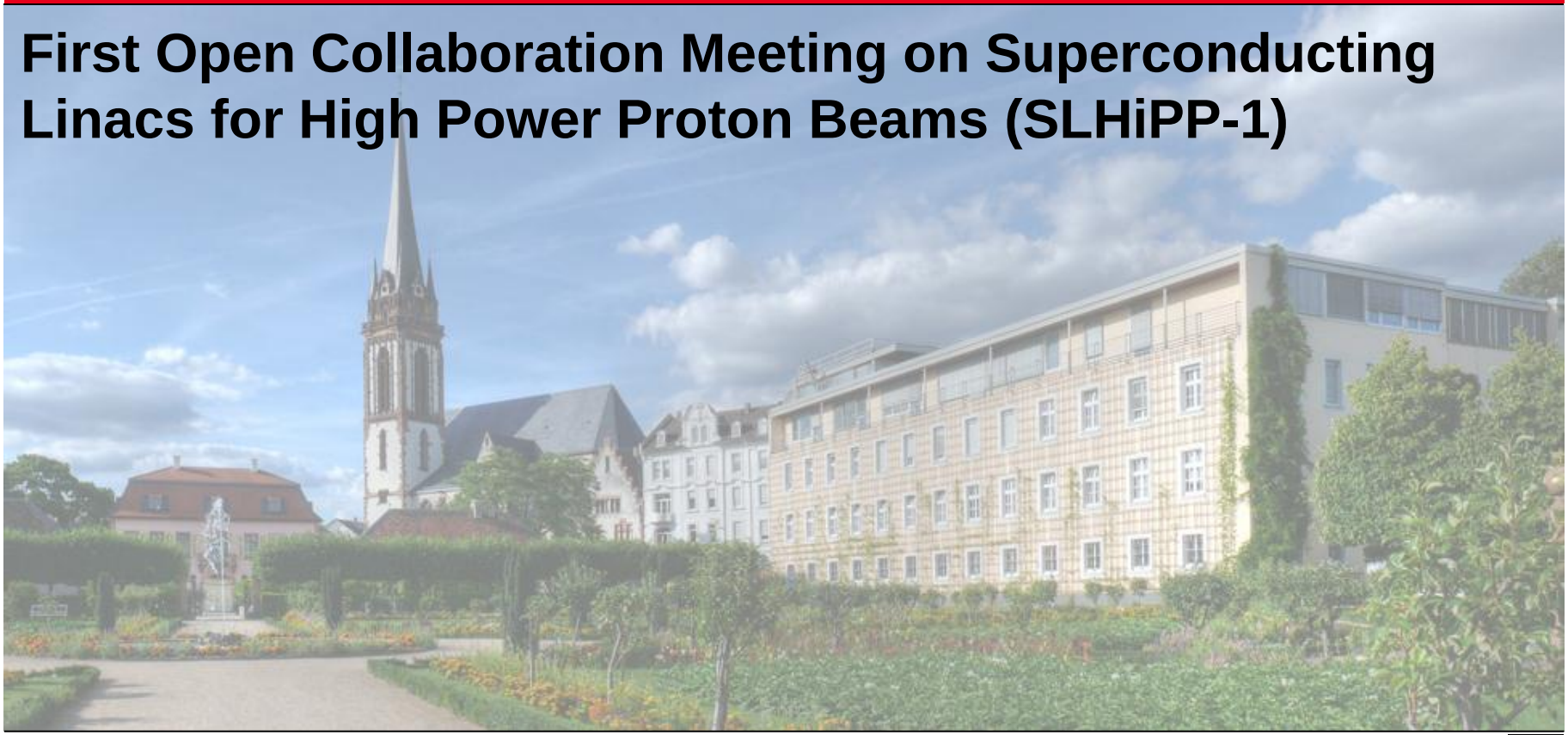
First Open Collaboration Meeting on Superconducting Linacs for High Power Proton Beams (SLHiPP-1)



Outline

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- Field simulation with hexahedron mesh in time domain
- Field simulation with hexahedron mesh in frequency domain
- Field simulation with tetrahedral mesh and higher order curvilinear elements
- Conclusion and Outlook

Field Simulation with Hexahedron Mesh in Time Domain

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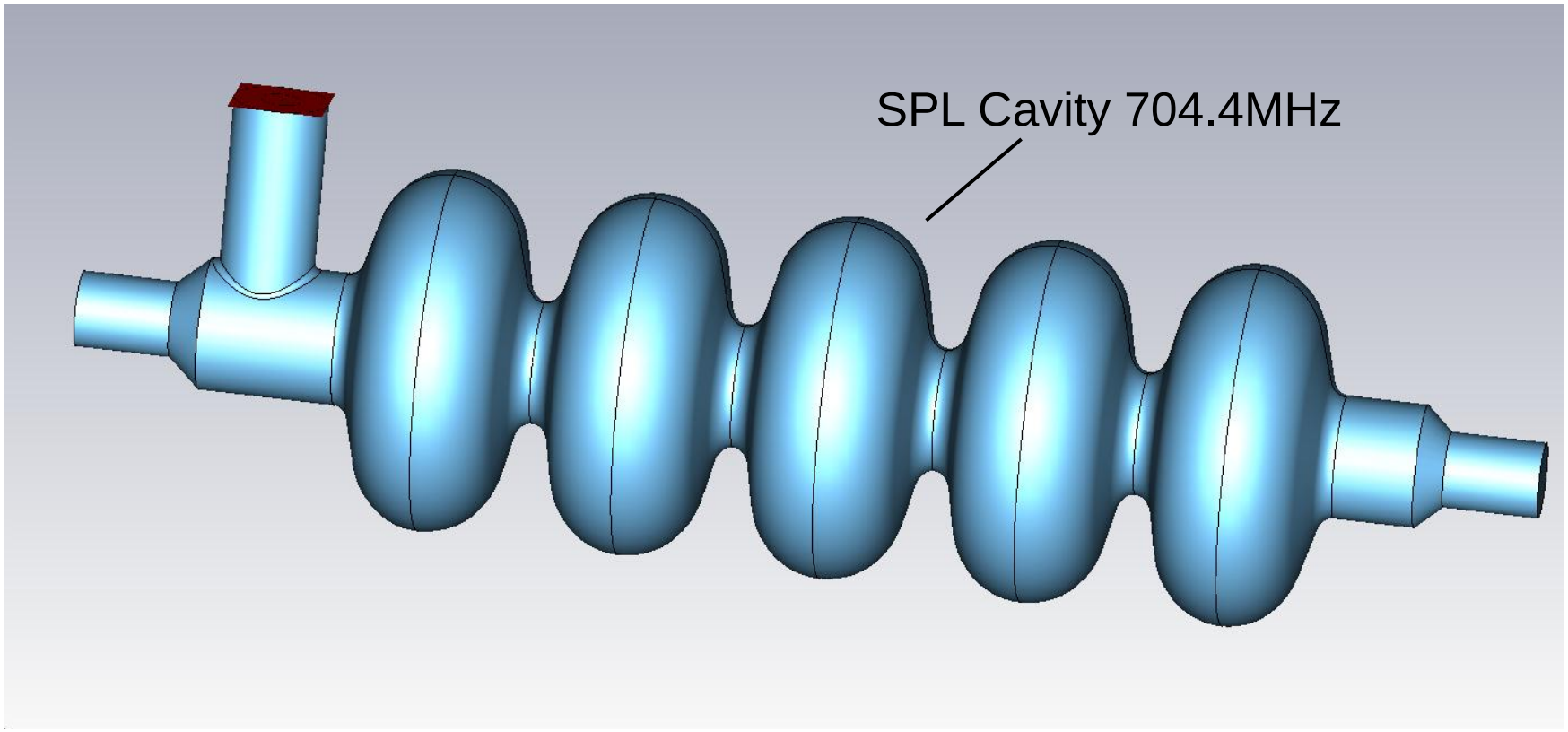
Calculation of eigenmodes frequencies and shunt impedances with Transient Solver in CST MICROWAVE STUDIO®



Field Simulation with Hexahedron Mesh in Time Domain

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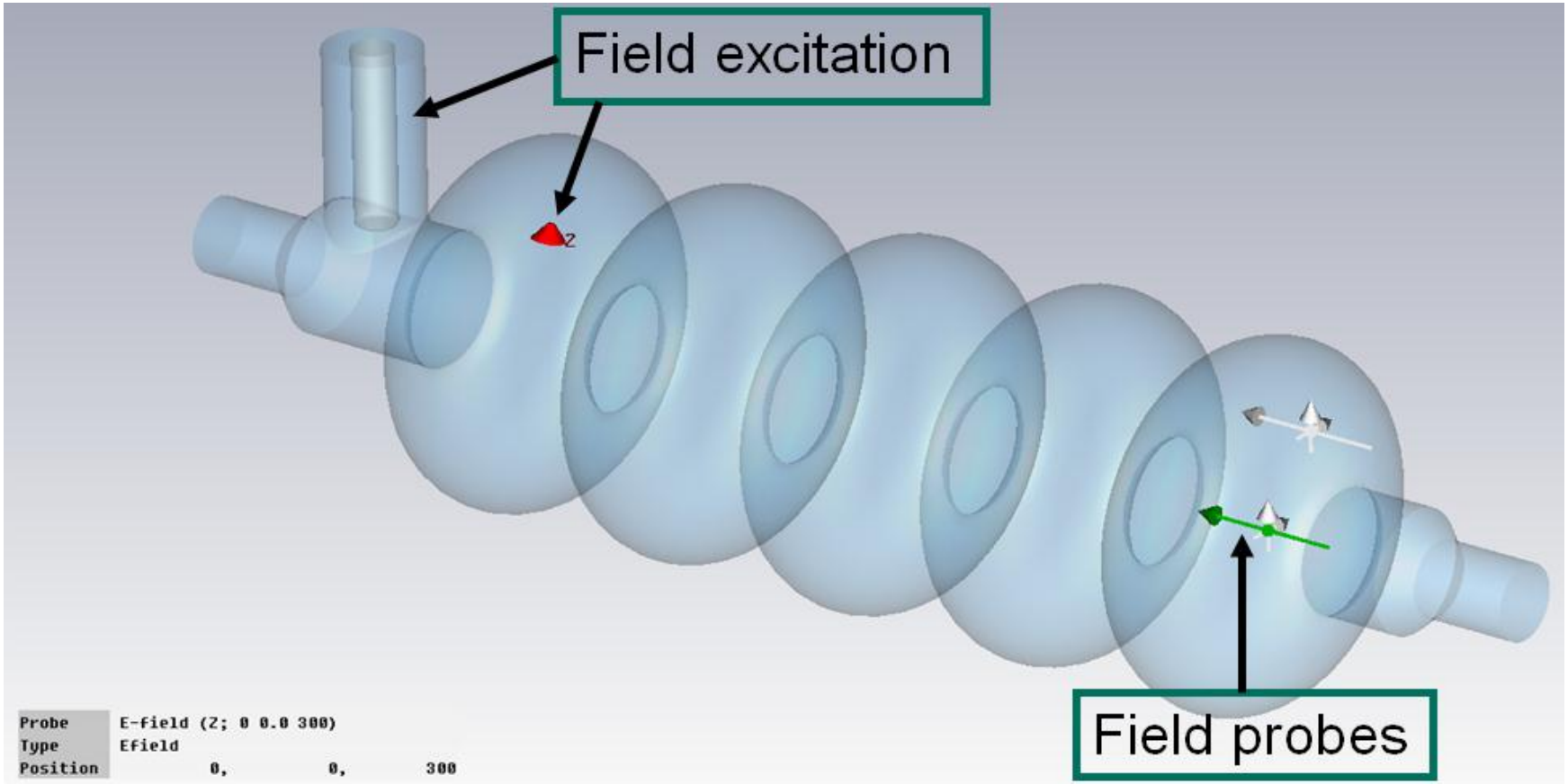
Detect and record the electromagnetic field in time domain



Field Simulation with Hexahedron Mesh in Time Domain

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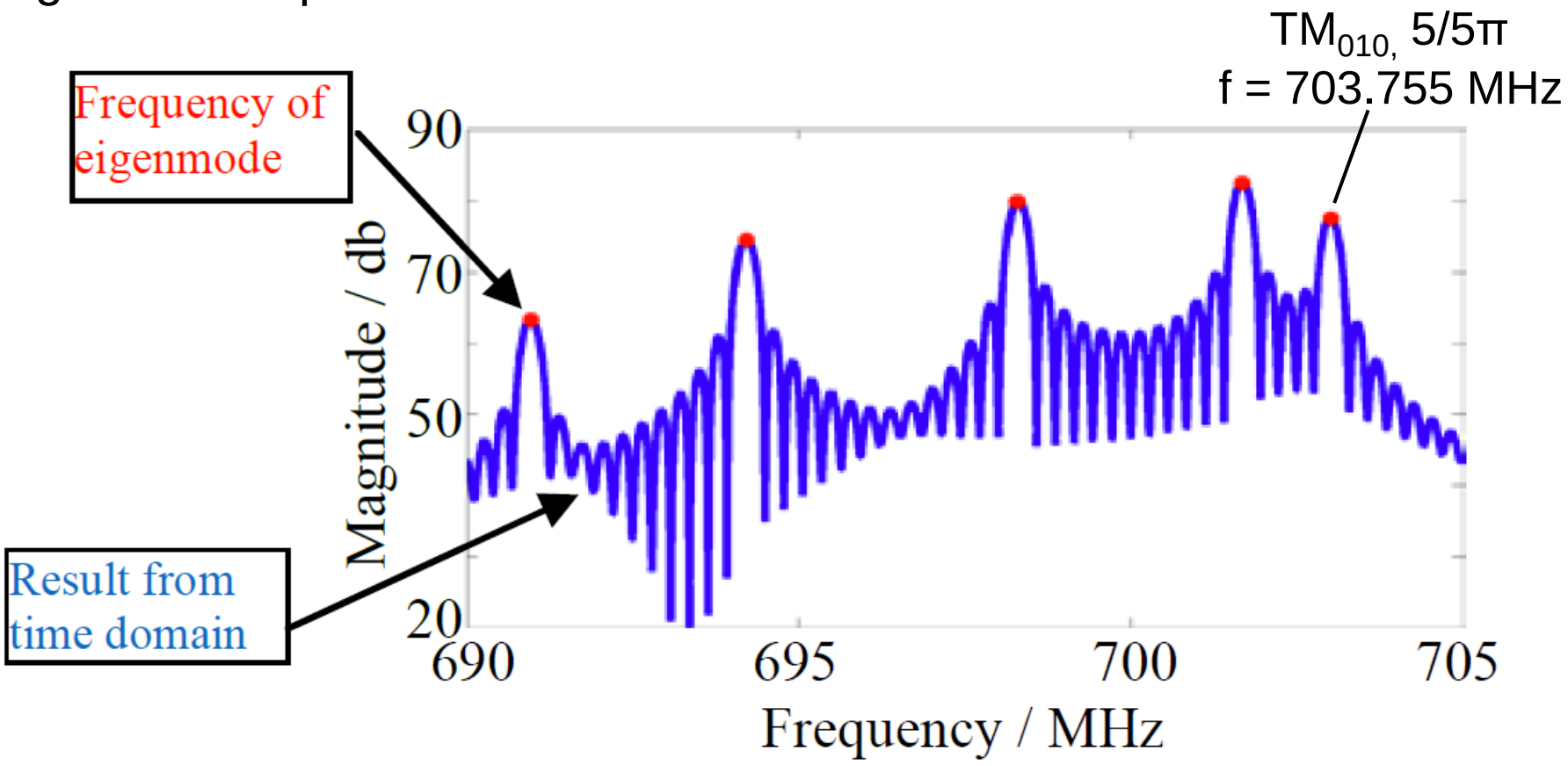
Eigenmode Spectrum TM110 Passband



Field Simulation with Hexahedron Mesh in Time Domain

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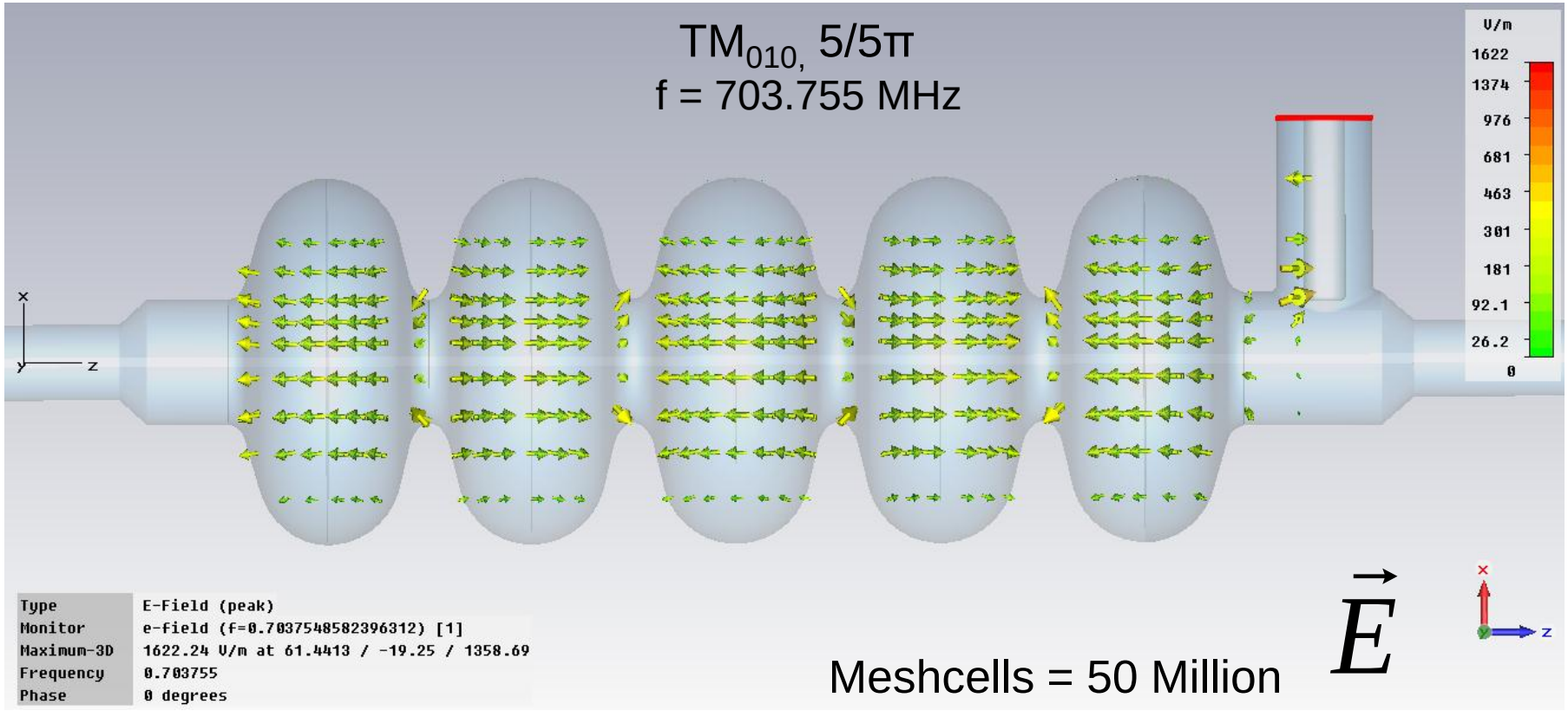
Field Monitor in Transient Solver can be defined

The field data of eigenmodes can be achieved after the second simulation



Field Simulation with Hexahedron Mesh in frequency Domain

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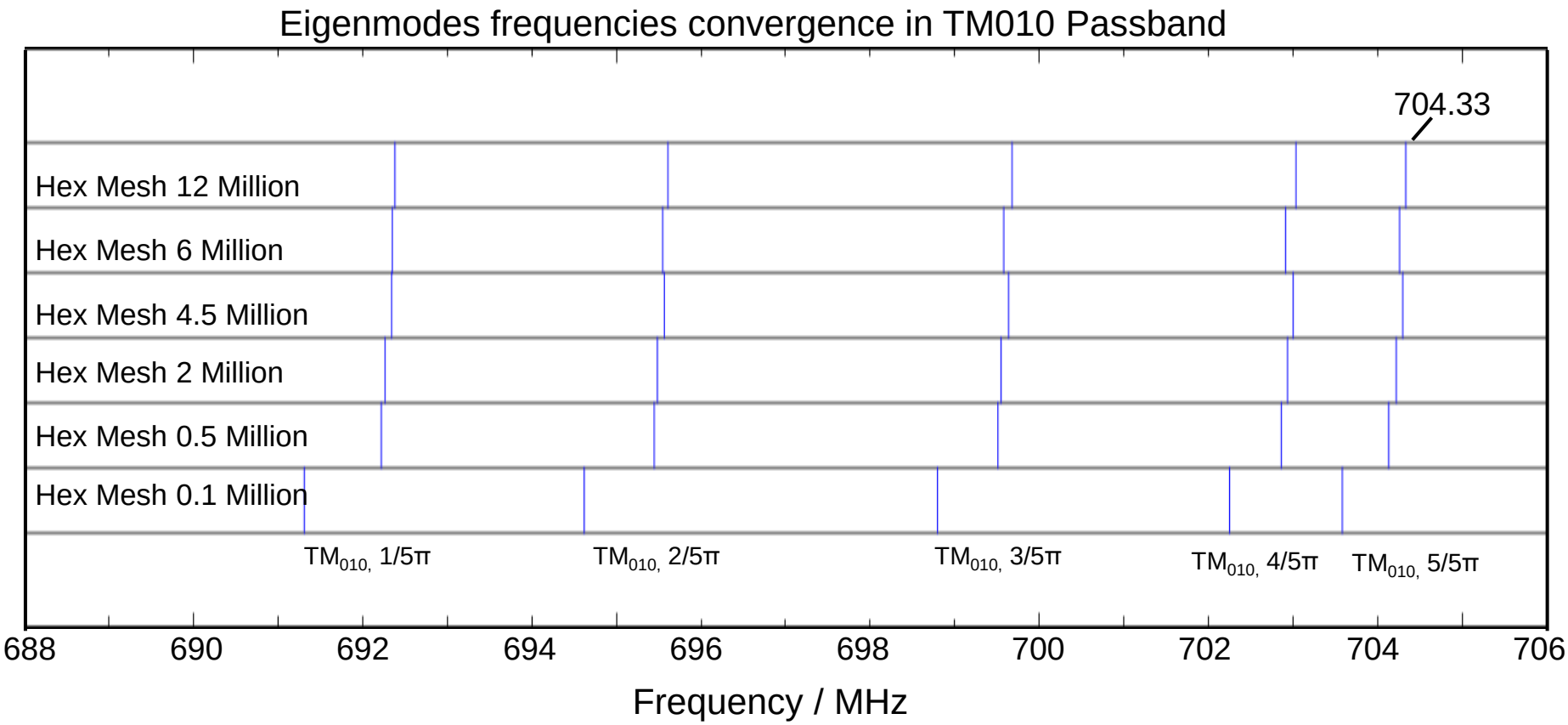
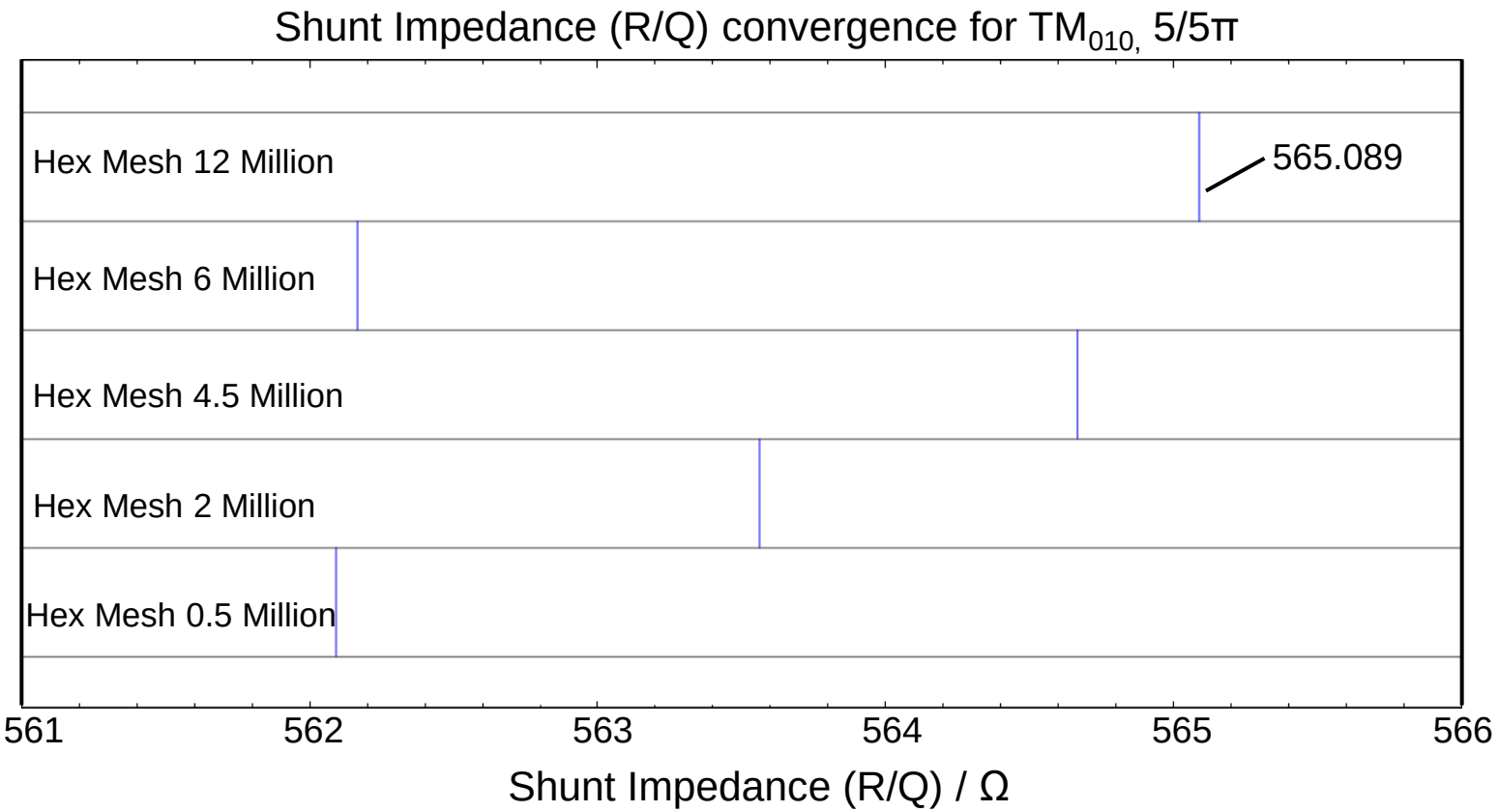
Calculation of eigenmodes frequencies and shunt impedances with Eigenmode Solver in CST MICROWAVE STUDIO®



Field Simulation with Hexahedron Mesh in frequency Domain



Slow convergence of frequency and shunt impedance (R/Q) !

Field Simulation with Tetrahedral Mesh and Higher Order Curvilinear Elements

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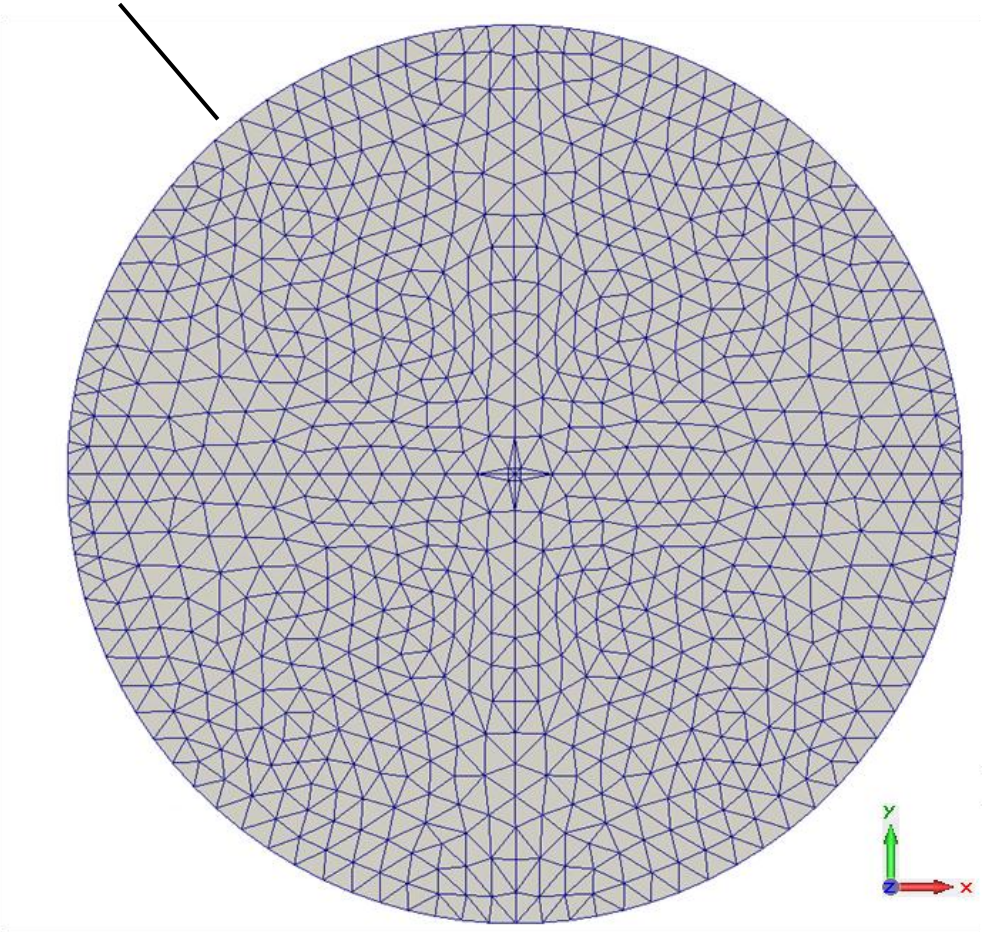
Symmetric tetrahedral mesh grids



Field Simulation with Tetrahedral Mesh and Higher Order Curvilinear Elements

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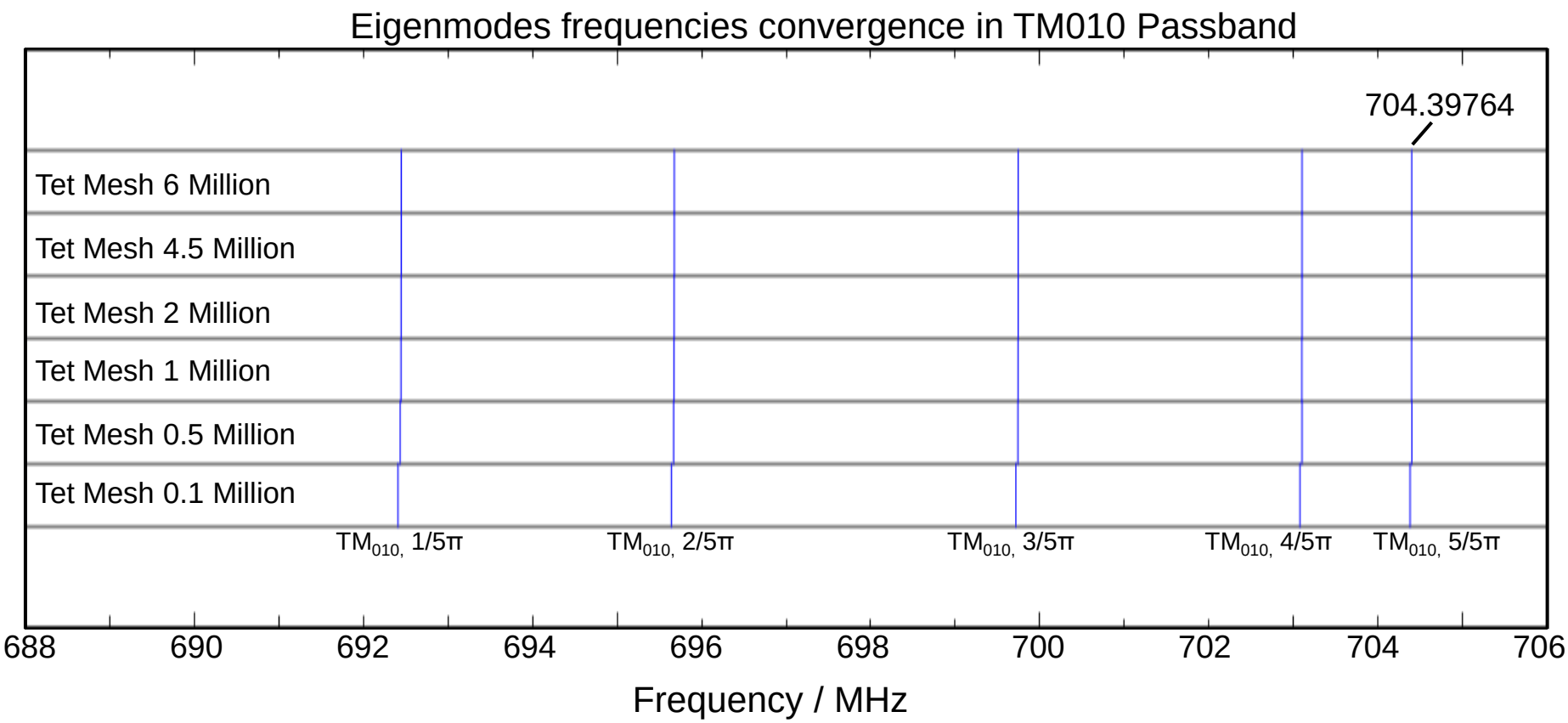
Fast convergence of frequency



Field Simulation with Tetrahedral Mesh and Higher Order Curvilinear Elements

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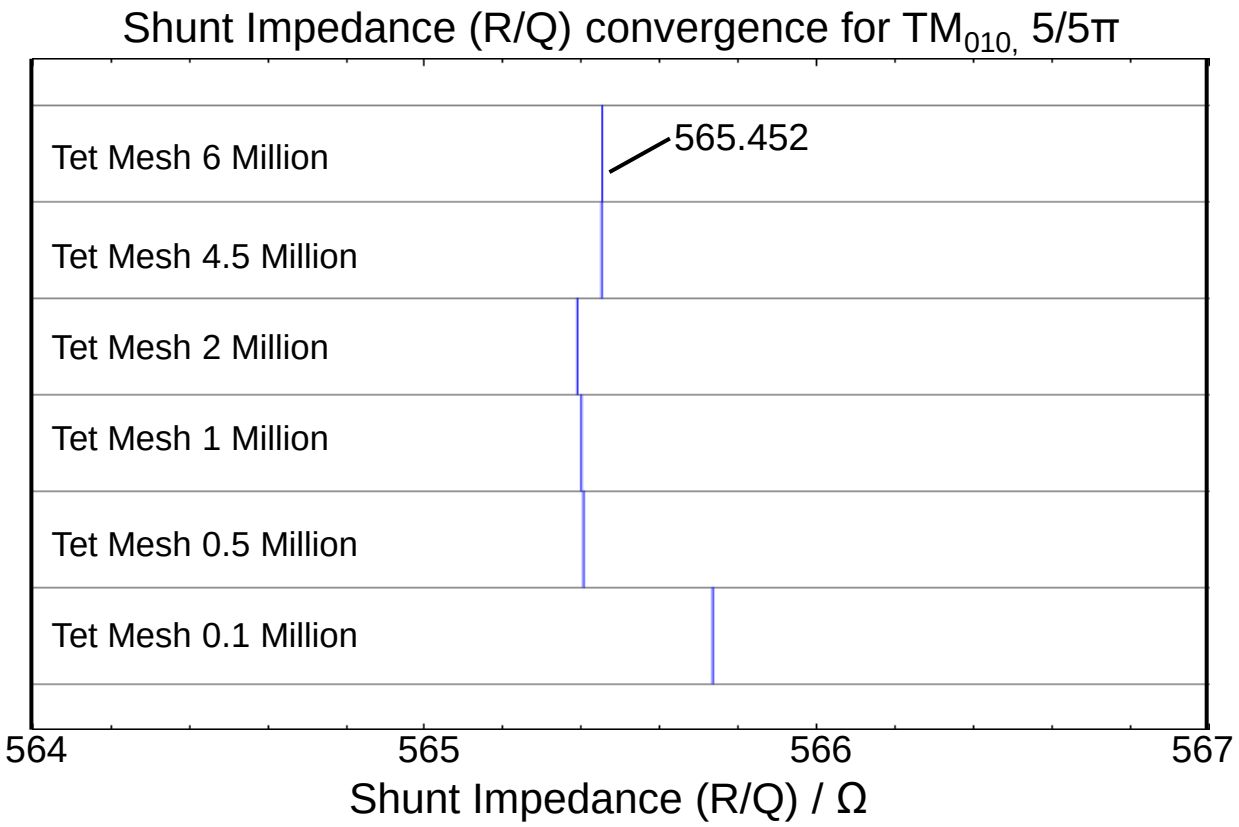
Fast convergence of shunt impedance (R/Q)



Field Simulation with Tetrahedral Mesh and Higher Order Curvilinear Elements

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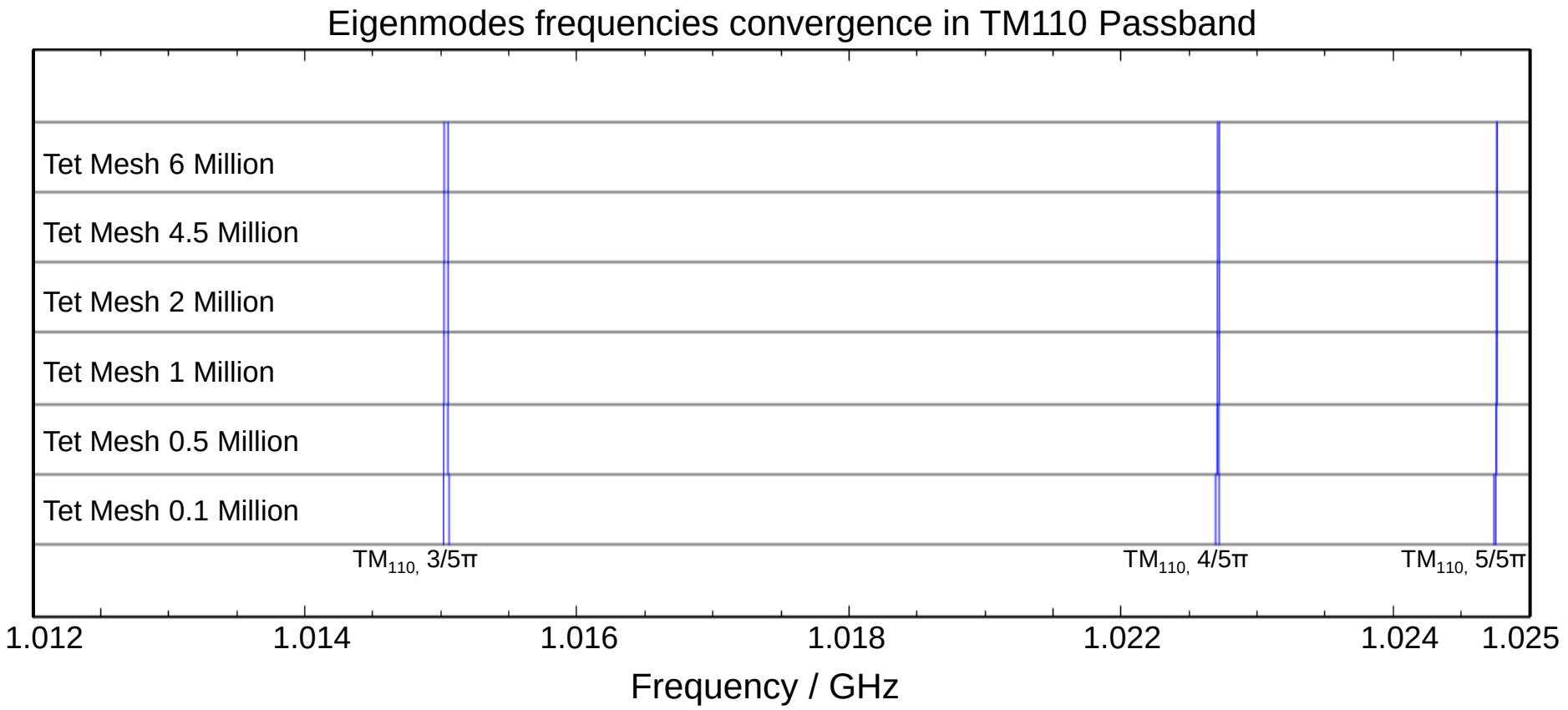
Fast convergence of HOM's frequencies



Field Simulation with Tetrahedral Mesh and Higher Order Curvilinear Elements

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HOM's mode with higher *R/Q* values (β = 1)

Monopole modes (Longitudinal *R/Q*)		
Mode	*f* [MHz]	*R/Q* [Ω]
$TM_{011,}$ 1/5π	1335.696481	104.388
$TM_{011,}$ 2/5π	1329.385480	57.364200
$TM_{011,}$ 3/5π	1317.323444	10.835400

Dipole modes (Transversal *R/Q*)		
Mode	*f* [MHz]	*R/Q* [Ω/m]
$TE_{111,}$ 3/5π	917.86077673	40.9000
$TE_{111,}$ 4/5π	943.04379569	67.6544
$TE_{111,}$ 5/5π	968.86849368	19.2868
$TM_{110,}$ 2/5π	1004.05346947	20.3753
$TM_{110,}$ 3/5π	1015.05261715	37.7503

Field Simulation with Tetrahedral Mesh and Higher Order Curvilinear Elements

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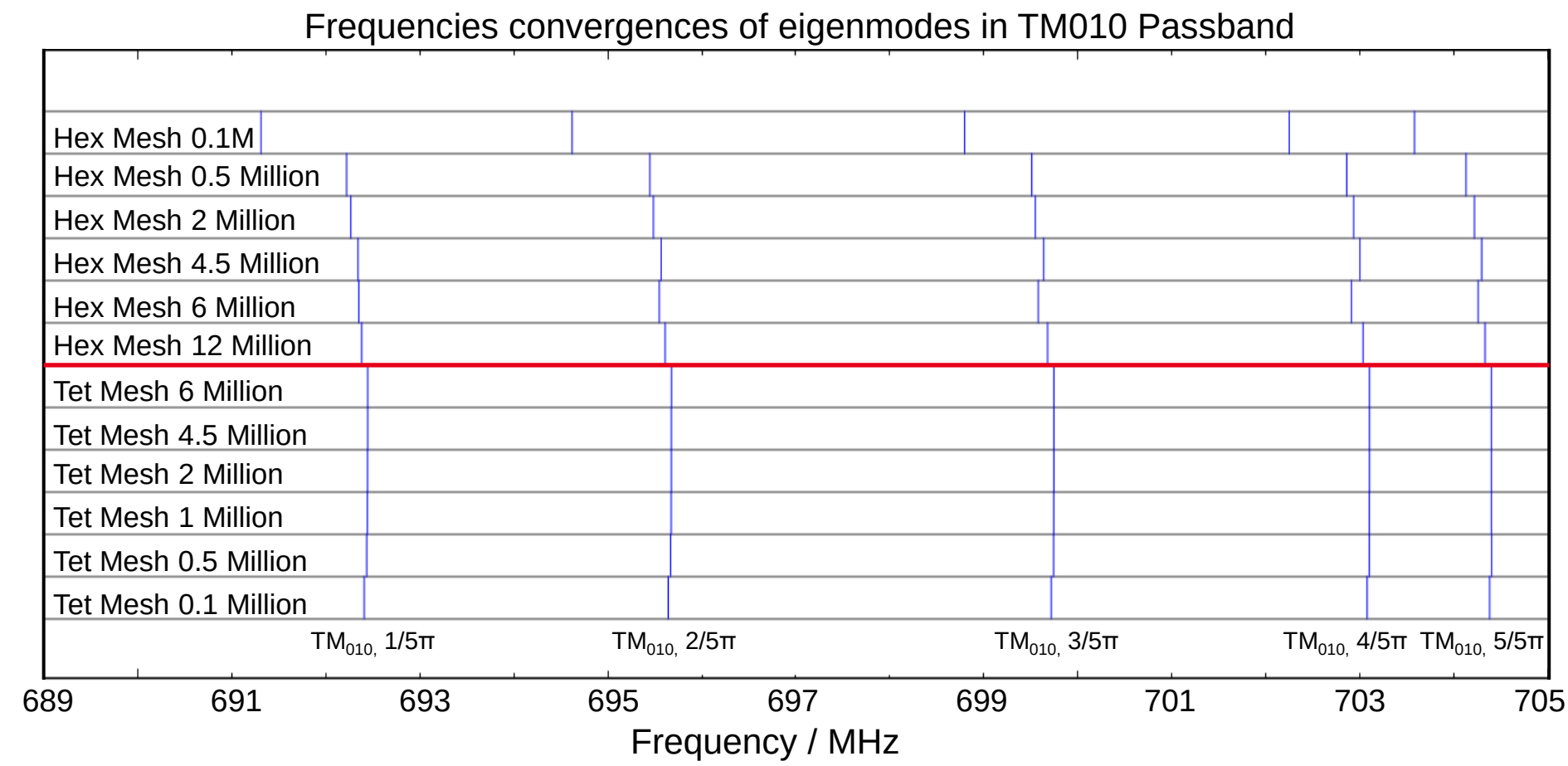
Comparison with the Hexahedron Mesh method in frequency domain



Field Simulation with Tetrahedral Mesh and Higher Order Curvilinear Elements

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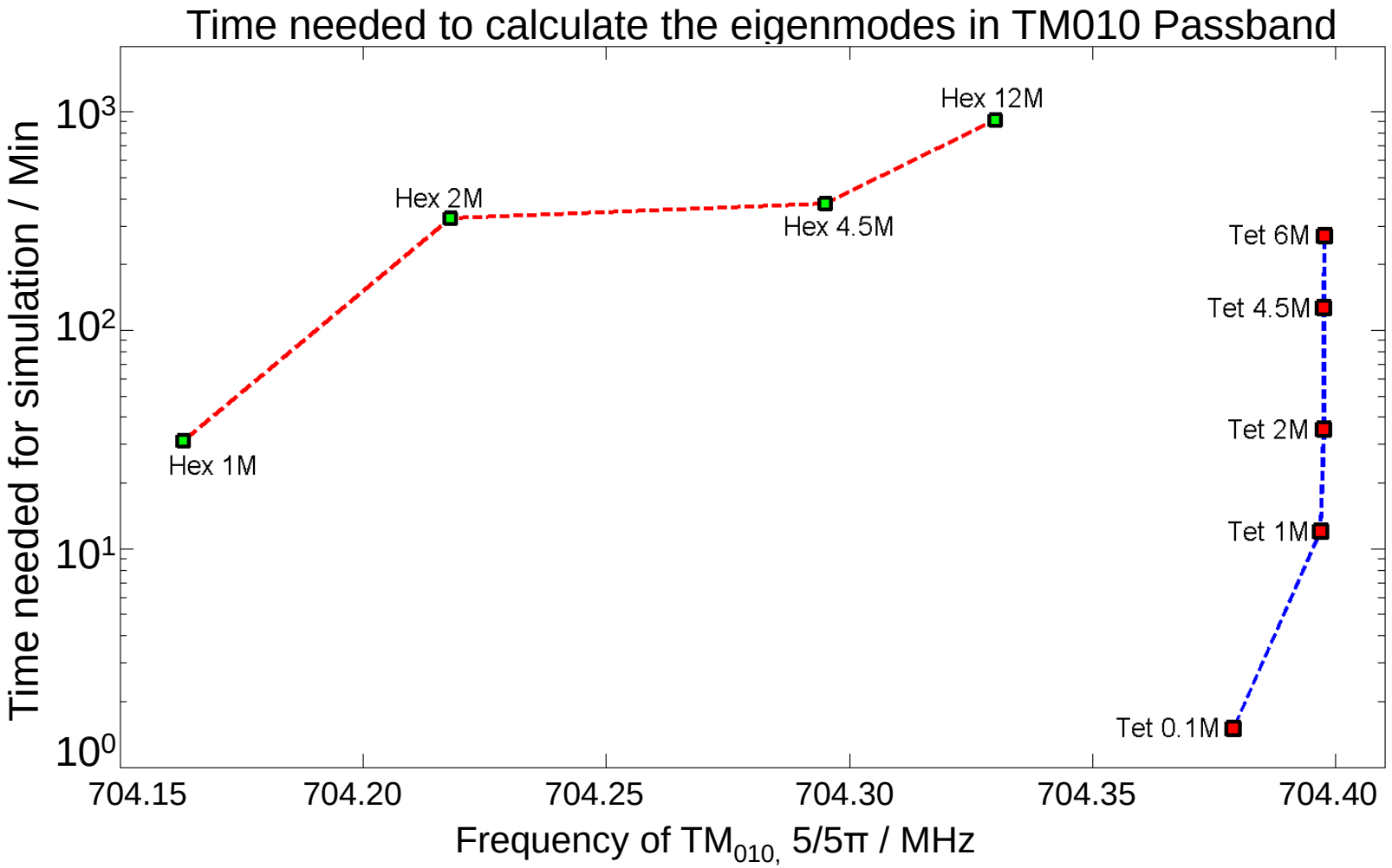

Conclusion and Outlook

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- The eigenmode analysis with hexahedral mesh grids in frequency domain and time domain are not ideal approaches to electromagnetic field simulations for elliptical SPL cavity.

- The eigenmode analysis with tetrahedral mesh grids and higher order curvilinear elements is highly efficient and accurate.

Conclusion and Outlook

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- The frequencies and the shunt impedances of higher order modes up to 3GHz will be calculated accurately.

- The HOM coupler will be considered for the effective damping of higher order modes in the SPL cavity.

Thank you for your attention!