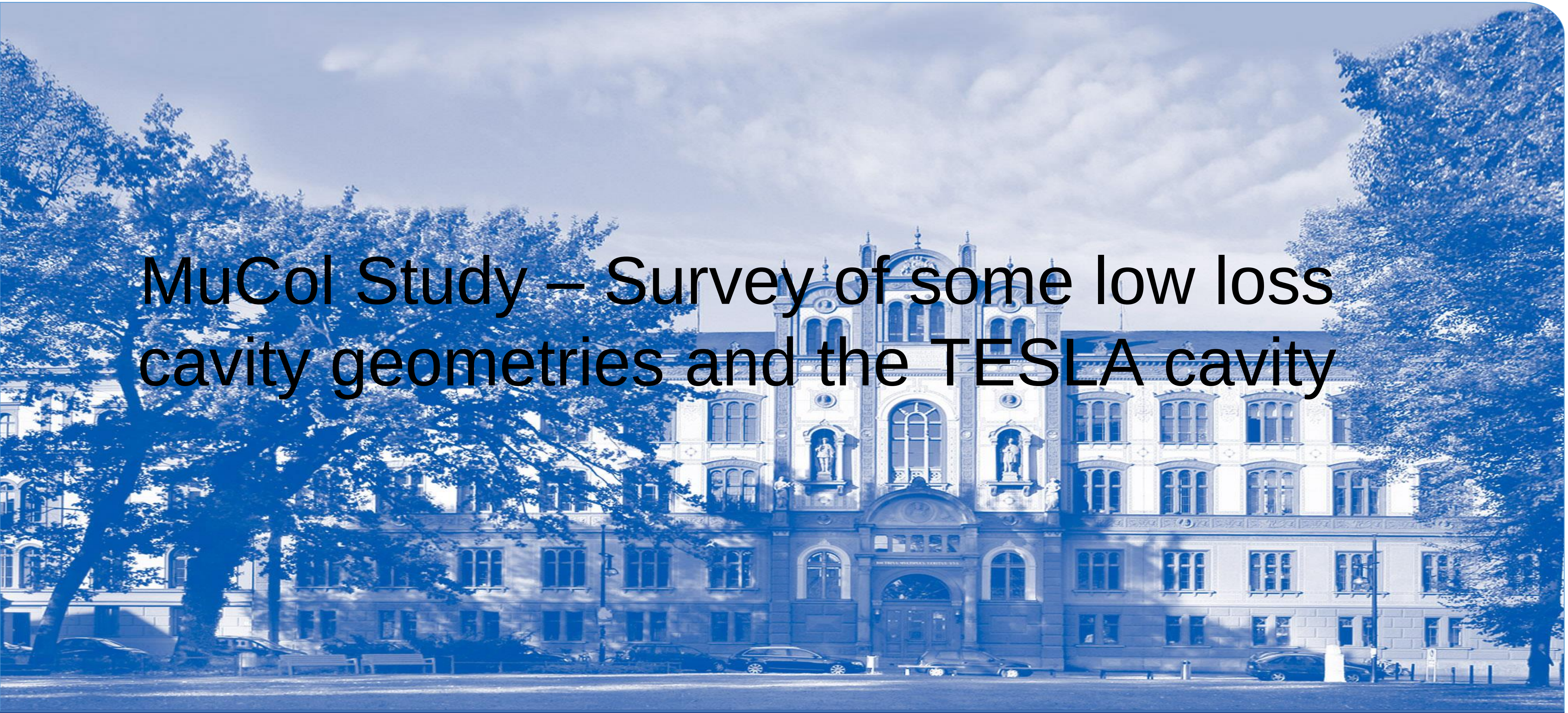
Universität Rostock

Traditio et Innovatio

MuCol Study – Survey of some low loss cavity geometries and the TESLA cavity



Some note

- The results of the analysis of the mid cell of the ILC-LL, ICHIRO, NLSF, NSLF-A and TESLA [1] cavities are presented

- Each cavity analysed comprised of 9 mid cells and no beam pipes for eigenmode analysis and with beampipes for wakefield analysis

[1] N. Juntong, R.M. Jones, High-gradient SRF Cavity with minimized surface E.M. fields and superior bandwidth for the ILC, Proceedings of SRF2009, Berlin, Germany. https://accelconf.web.cern.ch/SRF2009/papers/thppo024.pdf

Some Formulas

$$L_{\text{active}} = \frac{N_{\text{cell}}\lambda_0}{2} \qquad L_{\text{cavity}} = L_{\text{active}} + 2\lambda_0$$

L_{active}: Active cavity length, N_{cell}: Number of cells per cavity, λ_0: Accelerating mode wavelength, L_{cavity}: Total cavity length (with beampipes), E_{acc}: Accelerating gradient, V_{rf}: RF voltage

$$N_{\text{cav}} = \frac{V_{\text{rf}}}{E_{\text{acc}} \cdot L_{\text{active}}}$$

$$k_{\parallel,\text{FM}} = \frac{\omega_{\text{FM}}}{4}\left(\frac{R}{Q}\right)_{\parallel,\text{FM}} \text{e}^{-\left(\frac{\omega_{\text{FM}}\sigma_z}{c}\right)^2}$$

$k_{\parallel,\text{FM}}$: Fundamental mode loss factor, ω_{FM}: Fundamental mode angular frequency, σ_z: Bunch length, $\left(\frac{R}{Q}\right)_{\parallel,\text{FM}}$: Fundamental mode R/Q, c: Speed of light

$$k_{\text{HOM}} = k_{\parallel} - k_{\parallel,\text{FM}}$$

k_{HOM}: Higher order mode power loss factor, $k_{\parallel}$: Total loss factor

$$P_{\text{HOM}} = k_{\parallel,\text{HOM}} I_0 e N_{\text{b}}$$

P_{HOM}: Higher order mode power, I_0: Beam current, e: muon charge, N_b: Bunch intensity

$$P_{\text{dyn}} = V_{\text{rf}} \frac{E_{\text{acc}} \cdot L_{\text{active}}}{\frac{R}{Q}_{\parallel,\text{FM}} \cdot Q_0}$$

P_{dyn}: Dynamic power loss

$$P_{\text{stat}} = \frac{L_{\text{cavity}} \cdot V_{\text{rf}}}{L_{\text{active}} \cdot E_{\text{acc}}}$$

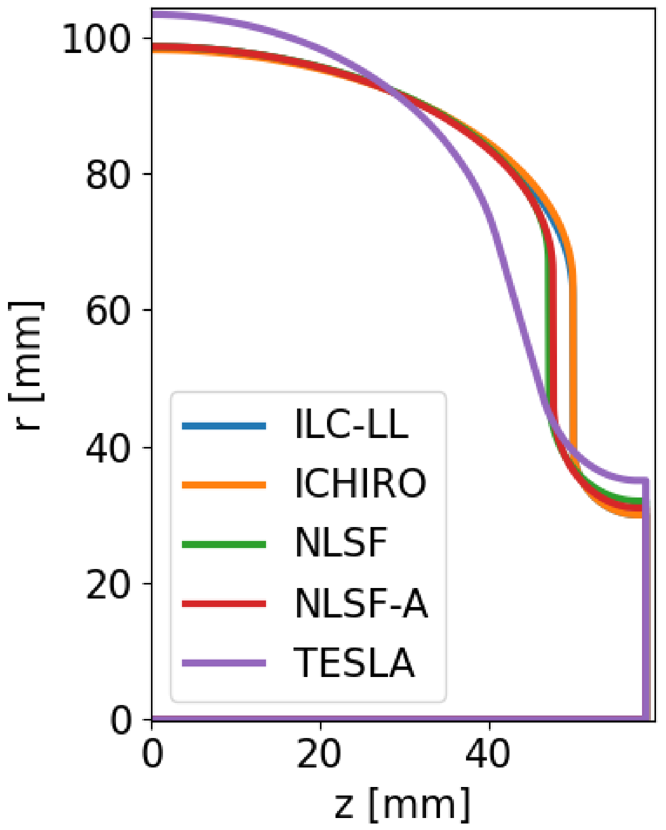
P_{stat}: Static power loss

$$P_{\text{dyn}}/\text{cav} = \frac{P_{\text{dyn}}}{N_{\text{cav}}},\ P_{\text{stat}}/\text{cav} = \frac{P_{\text{stat}}}{N_{\text{cav}}}$$

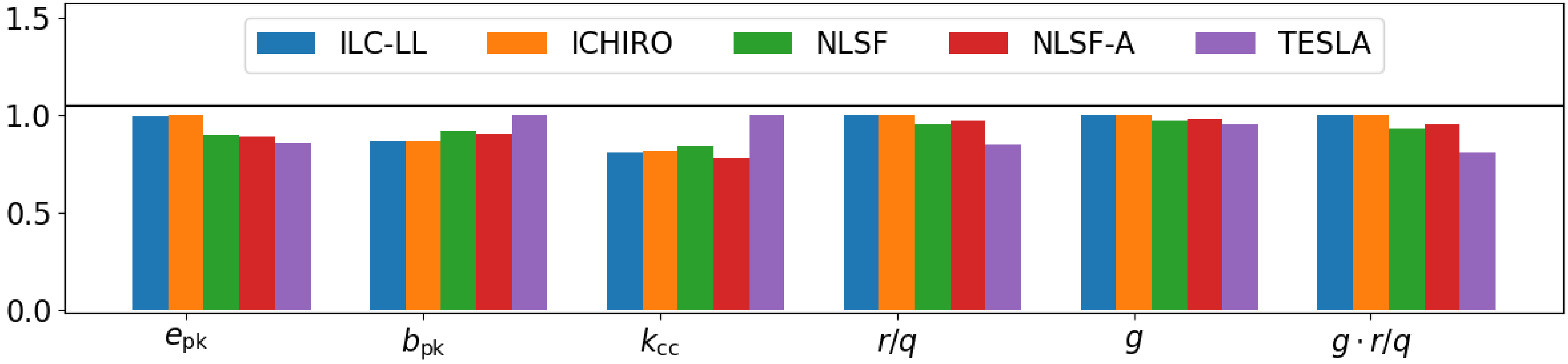
Summary Table

	ILC-LL	ICHIRO	NLSF	NLSF-A	TESLA
A [mm]	50.05/50.05	50.05/50.05	47.15/47.15	47.65/47.65	42/42
B [mm]	36.5/36.5	34.22/34.22	31.35/31.35	32.91/32.91	42/42
a [mm]	7.6/7.6	7.6/7.6	10.5/10.5	10.0/10.0	12/12
b [mm]	10/10	9.95/9.95	15.5/15.5	15.5/15.5	19/19
R_i	30/30	30/30	32/32	31/31	35/35
L [mm]	57.7/57.7	57.7/57.7	57.7/57.7	57.7/57.7	57.7/57.7
R_{eq} [mm]	98.58/98.58	98.14/98.14	98.58/98.58	98.58/98.58	103.3/103.3
$\alpha[°]$	90.12/90.12	90.11/90.11	90.14/90.14	90.14/90.14	103.31/103.31
$R/Q[\Omega]$	1201.25	1204.0	1148.32	1172.67	1022.88
$G[\Omega]$	284.44	283.91	276.66	277.98	271.33
$G.R/Q[10^4\Omega^2]$	341680.79	341827.26	317691.85	325982.38	277541.32
E_{pk}/E_{acc}	2.31	2.32	2.09	2.07	1.98
$B_{pk}/E_{acc}[\frac{mT}{MV/m}]$	3.62	3.61	3.84	3.77	4.17
$\lvert k_{FM}\rvert$[V/pC]	1.6507	1.6545	1.578	1.6114	1.4056
$\lvert k_{\parallel}\rvert$[SR][V/pC]	2.253	2.246	2.06	2.126	1.755
$k_{\perp}$[V/pC/m]	68.45	68.36	58.72	63.98	47.06
$N_{cav/beam}$	670	670	670	670	670
P_{stat}/cav[W]	7.44	7.44	7.44	7.44	7.44
P_{dyn}/cav[W]	96.83	96.73	106.51	103.04	126.0
P_{HOM}/cav[kW]	4.99	4.91	4.0	4.27	2.9

RCS Stage 1
Beam current – 20.38 mA
Bunch length – 23.1 mm

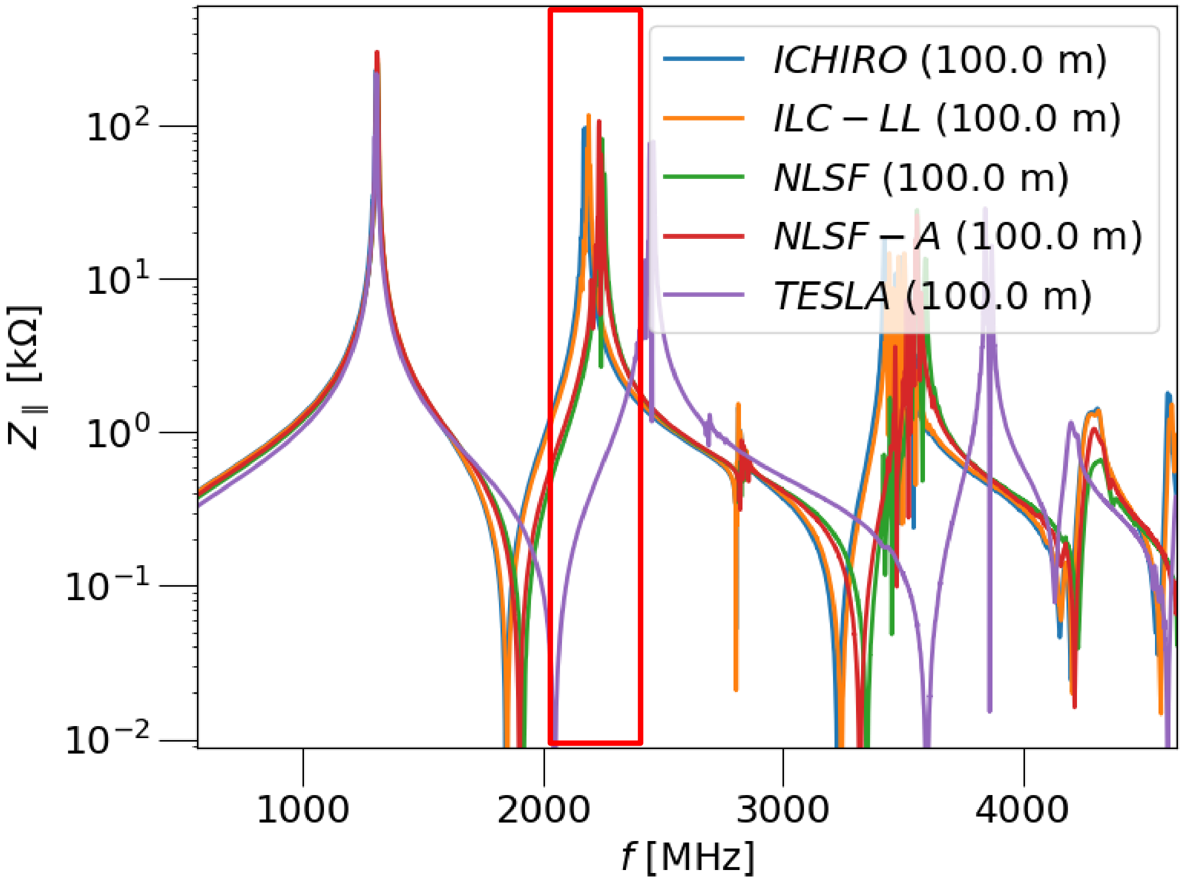


FM Quantities of Interest (QOIs)

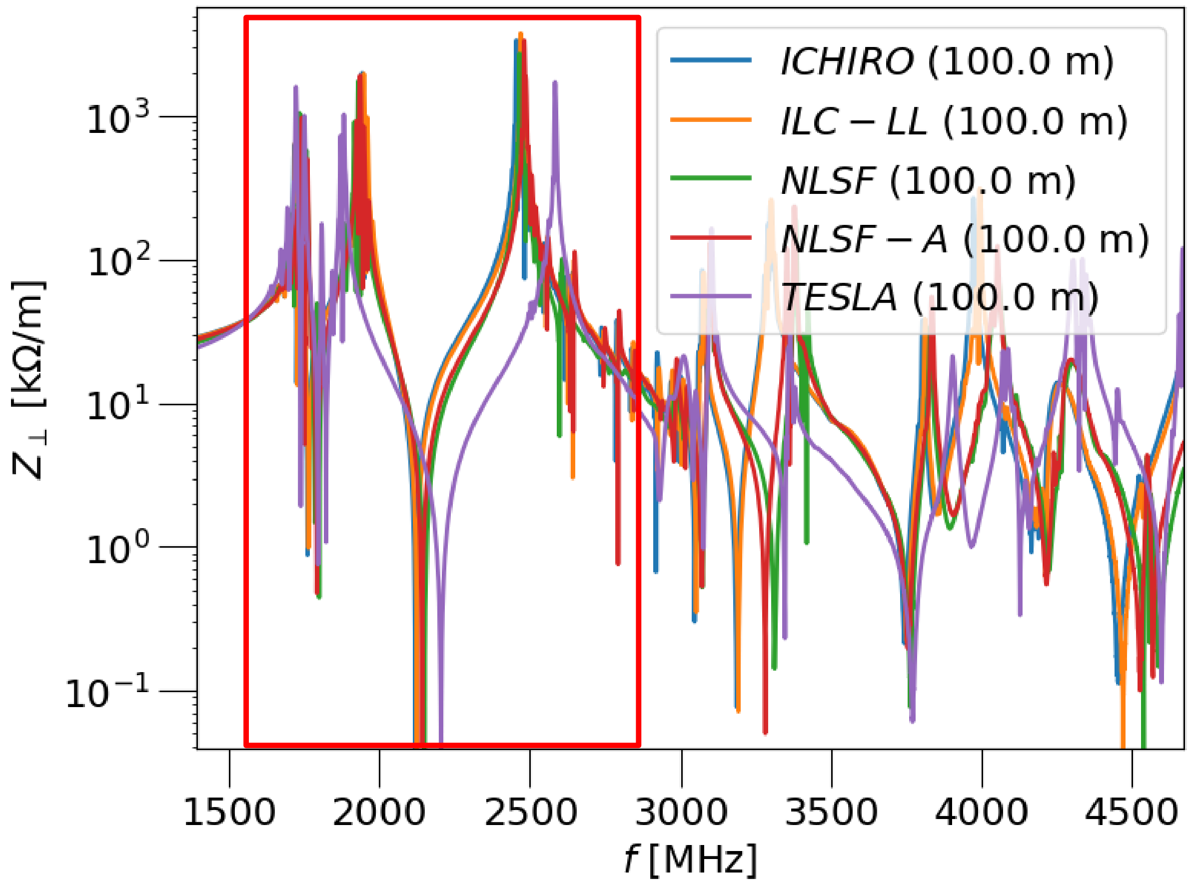


Bar plot of normalized fundamental mode quantities of interest

Wakefield Impedance – (100 m wakelength)

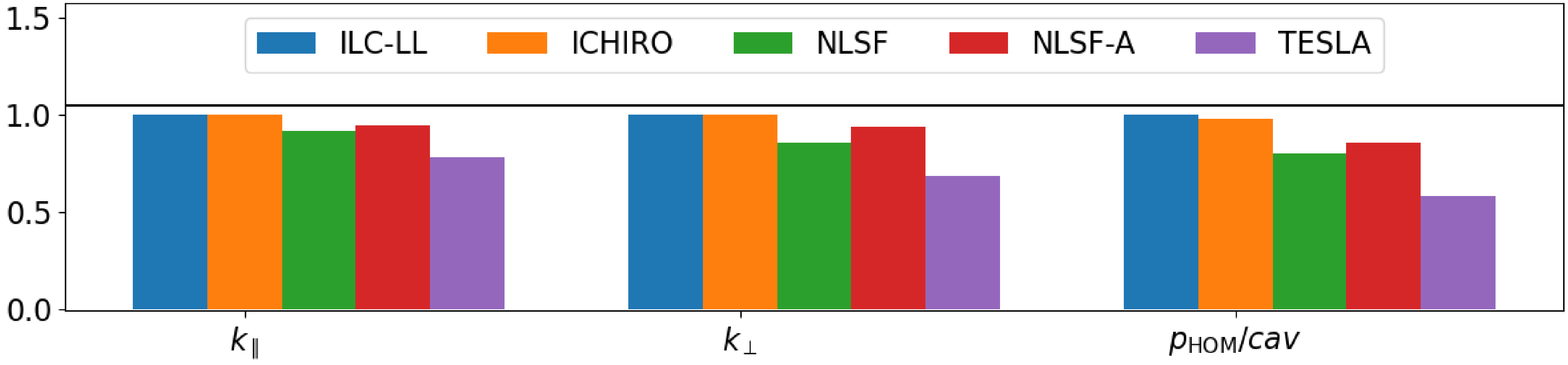


Longitudinal impedance plot



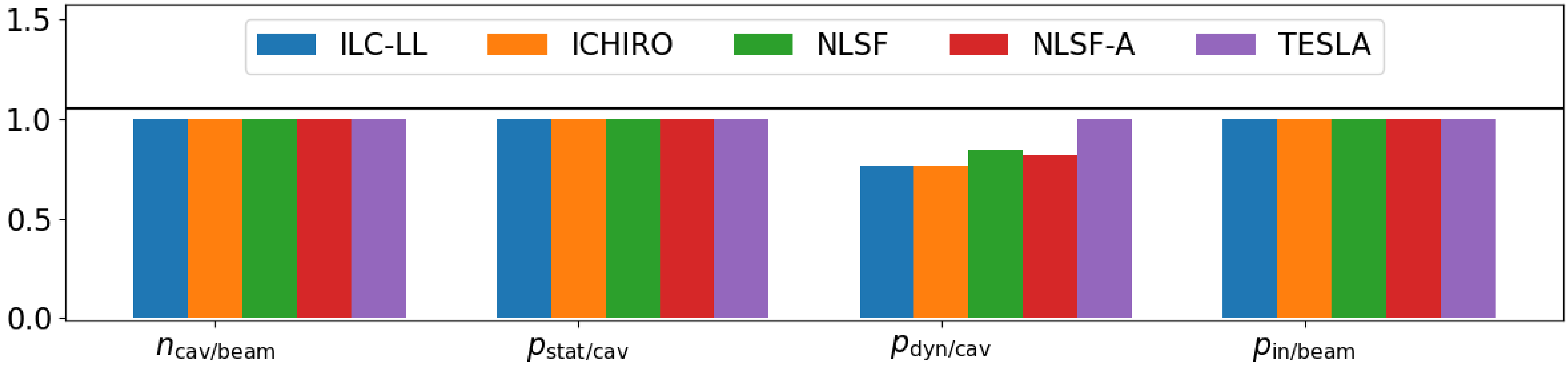
Transverse impedance plot

HOM QOIs



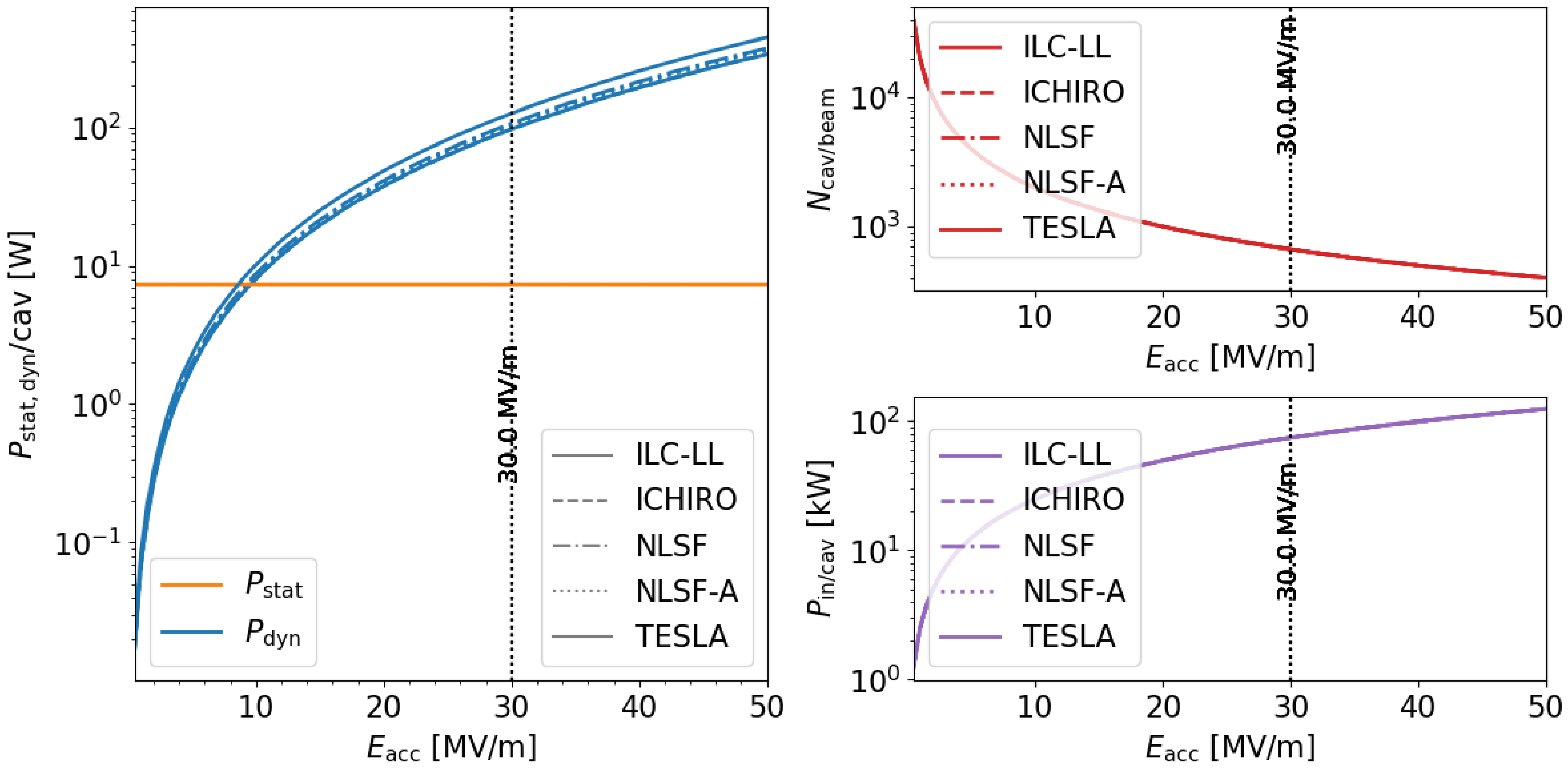
Bar plot of normalized loss and kick factors, and HOM power

Input Power and Power Loss



Bar plot of normalized number of cavities, static, dynamic power loss and input power

Input Power and Power Loss



$E_{acc} = 30$ MV/m

Plot of static and dynamic power loss, no of cav./beam and input power (P_{in}) vs E_{acc}.

End note

- The properties of the compared cavities were not drastically different from each other

- The end-cells of the compared cavities are not available to run a full analysis so the results only give a rough approximation of what is obtainable. The end-cell can be optimized to reduce the HOMs impedance, loss and kick factors

- Since the properties of the analysed cavities are quite similar, the impedance plots do not really show much. At this time, the threshold impedance values are not yet available