A HIGH PHASE ADVANCE DAMPED AND DETUNED STRUCTURE FOR THE MAIN LINACS OF CLIC

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ABSTRACT

The main accelerating structures for the CLIC are designed to operate at 100 MV/m accelerating gradient. The accelerating frequency has been optimised to 11.994 GHz with a phase advance of 2π/3 per cell [1] for the main accelerating mode. The moderately damped DDS design [2-3] is being studied as an alternative to the strongly damped WDS design [1]. Both these designs (DDS and WDS) are based on the nominal accelerating phase advance. Here we explore high phase advance (HPA) 5π/6 structures in which the group velocity of the rf fields is reduced compared to that of standard 2π/3 structures. The electrical breakdown strongly depends on the fundamental mode group velocity. Hence it is expected that electrical breakdown is less likely to occur in the HPA structures. Here we report on a study of both the fundamental and dipole modes in a DDS_ HPA structure, designed to operate at 5π/6 phase advance per cell.

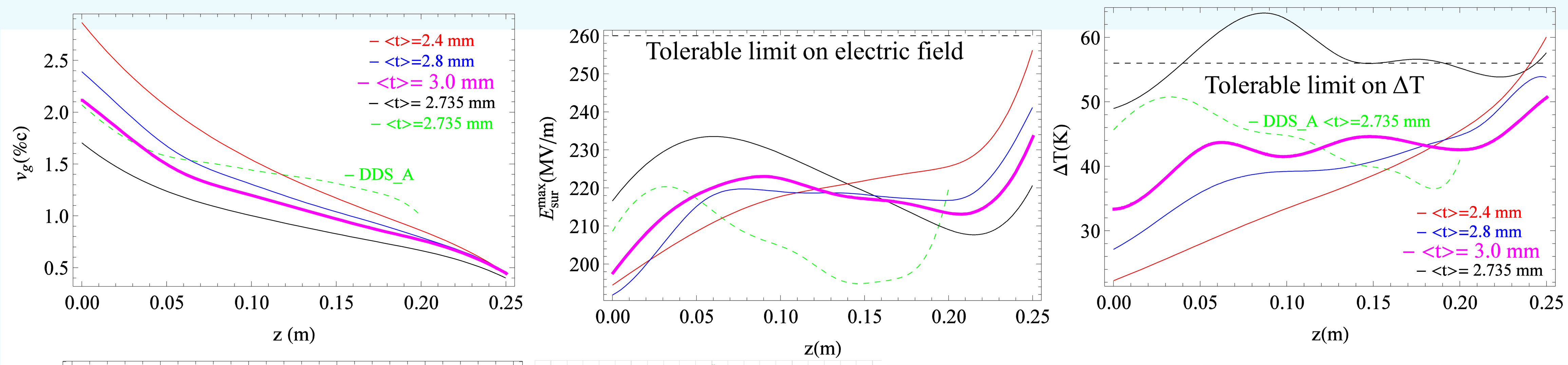
ACCELERATING MODE RF PROPERTIES OF CLIC_DDS_HPA

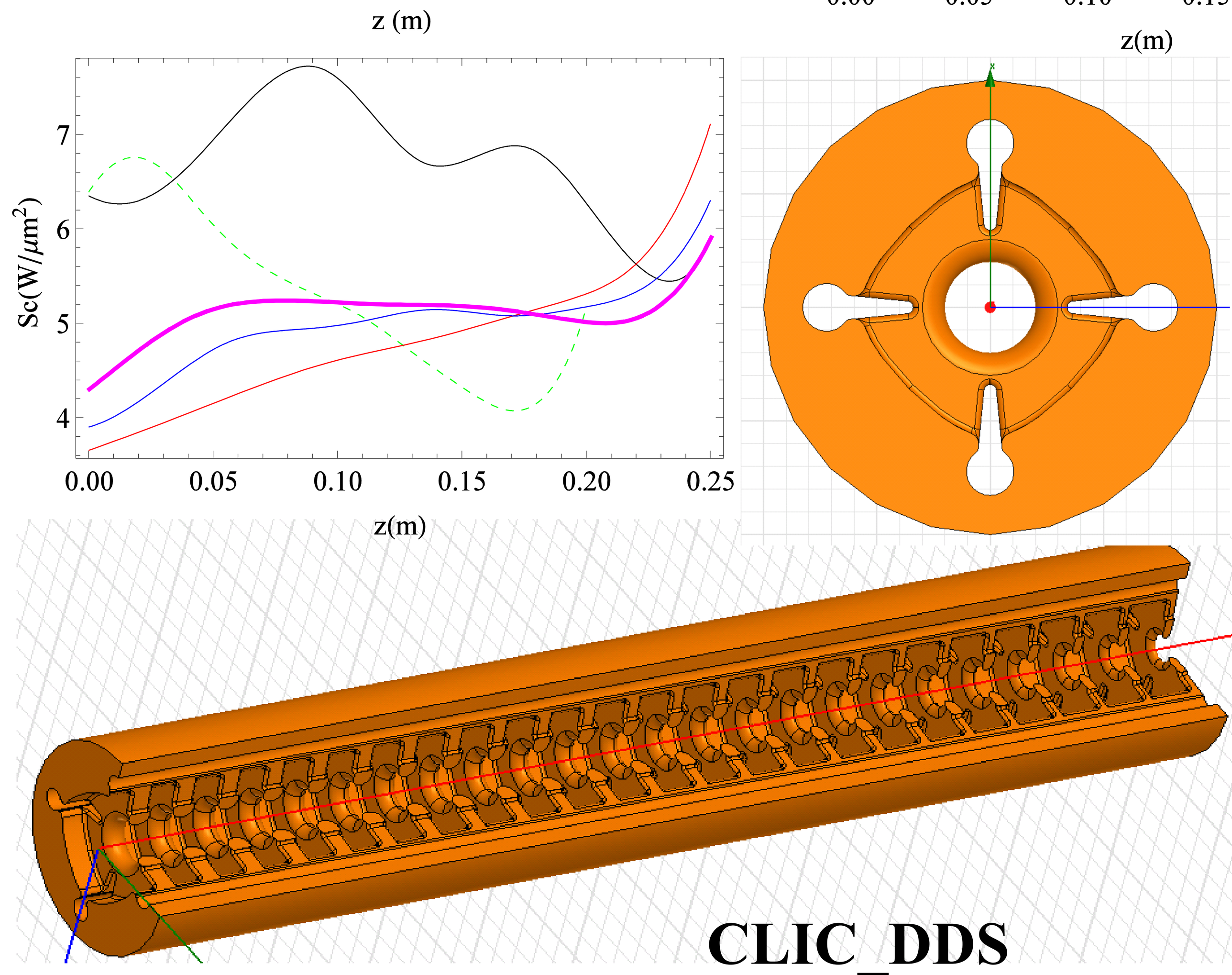
- Our design for CLIC aims at an average loaded gradient of ~100 MV/m at a pulse length of ~ 270 ns.
- Associated high surface e.m. fields cause electrical breakdown.
- High group velocity (v_g) and large input power are also known to exacerbate breakdown.
- Imperative to reduce the surface fields and v_g.
- Beam induces higher order modes which disrupt succeeding bunches.
- Critical to ensure the resulting wakefield is suppressed to manageable level.
- Finally, the overall "wall-plug" to beam efficiency must be optimised.
- We have developed a travelling wave structure of 24 cells, with a fundamental mode phase advance of 5π/6 per cell which we referred to as CLIC_DDS_HPA[4].

Group velocity of the fundamental mode is reduced.

- Optimised overall performance by varying the iris thickness (compared to CLIC_DDS_A[5]).
- Superior performance predicted compared to standard structure (in particular there is a reduced input power requirement) [4].
- Additional optimisation is in progress to enhance luminosity, in particular.

RF properties of DDS_HPA for a range of iris thicknesses



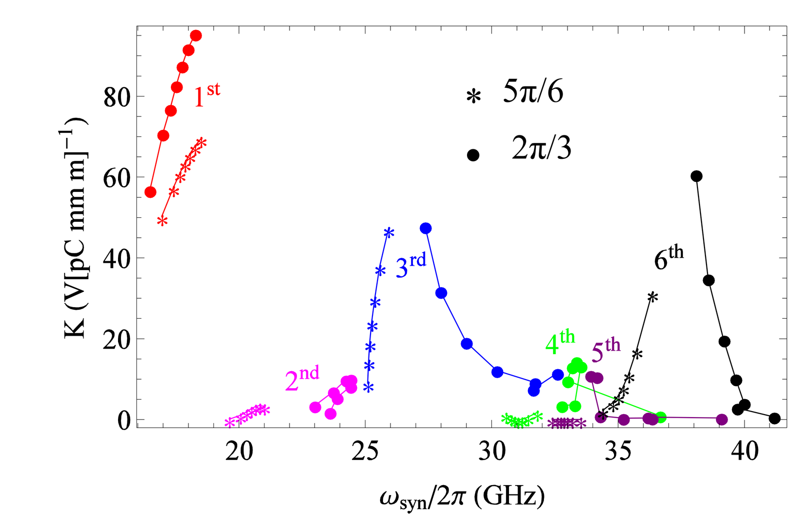


RF parameters	DDS_A	DDS_ HPA42	DDS_ HPA32
Iris thickness (In/Out)[mm]	4/1.47	3.2/2.8	3.2/2.8
Bunch population (n_b)[10^9]	4.2	4.2	3.2
Q (In/Out) [10^3]	5.0/6.5	6.9/7.0	6.9/7.0
R' (In/Out) [MΩ/m]	51/118	72 / 102	72/102
Group velocity, v_g/c (In/Out) [%]	2.07/1.0	2.1 / 0.45	2.1 / 0.45
P_{in} [MW]	71	68.2	63.6
Acc. grad (E_{acc}) (Load./UnL.) [MV/m]	105/132	93/143	90/138
Pulsed temp. rise (ΔT_{sur}) [ºK]	51	51	48
Surface electric field (E_{sur}) [MV/m]	220	234	225
Modified Poynting vector (S_c) [W/μm²]	6.75	5.9	5.5
RF-to-beam efficiency. (η)[%]	23.5	29	23.3

HIGHER BAND DIPOLE MODES IN HPA STRUCTURE

- We utilise the code *TRANSVRS* [6] to rapidly calculate the first six band dipole modes in CLIC_DDS_HPA.
- We characterise the smooth geometry by sharp transitions – a requirement of TRANSVRS.
- The kick factors for the 5π/6 structure are contrasted with the standard 2π/3 structure (rightmost).
- Overall summation of the kick factors is reduced ~ 15% compared to CLIC_DDS_A
- Main contribution to the fields is confined by the 1st , 3rd and 6th bands – dominated by the first band.
- We focus our study on suppressing the first dipole band.

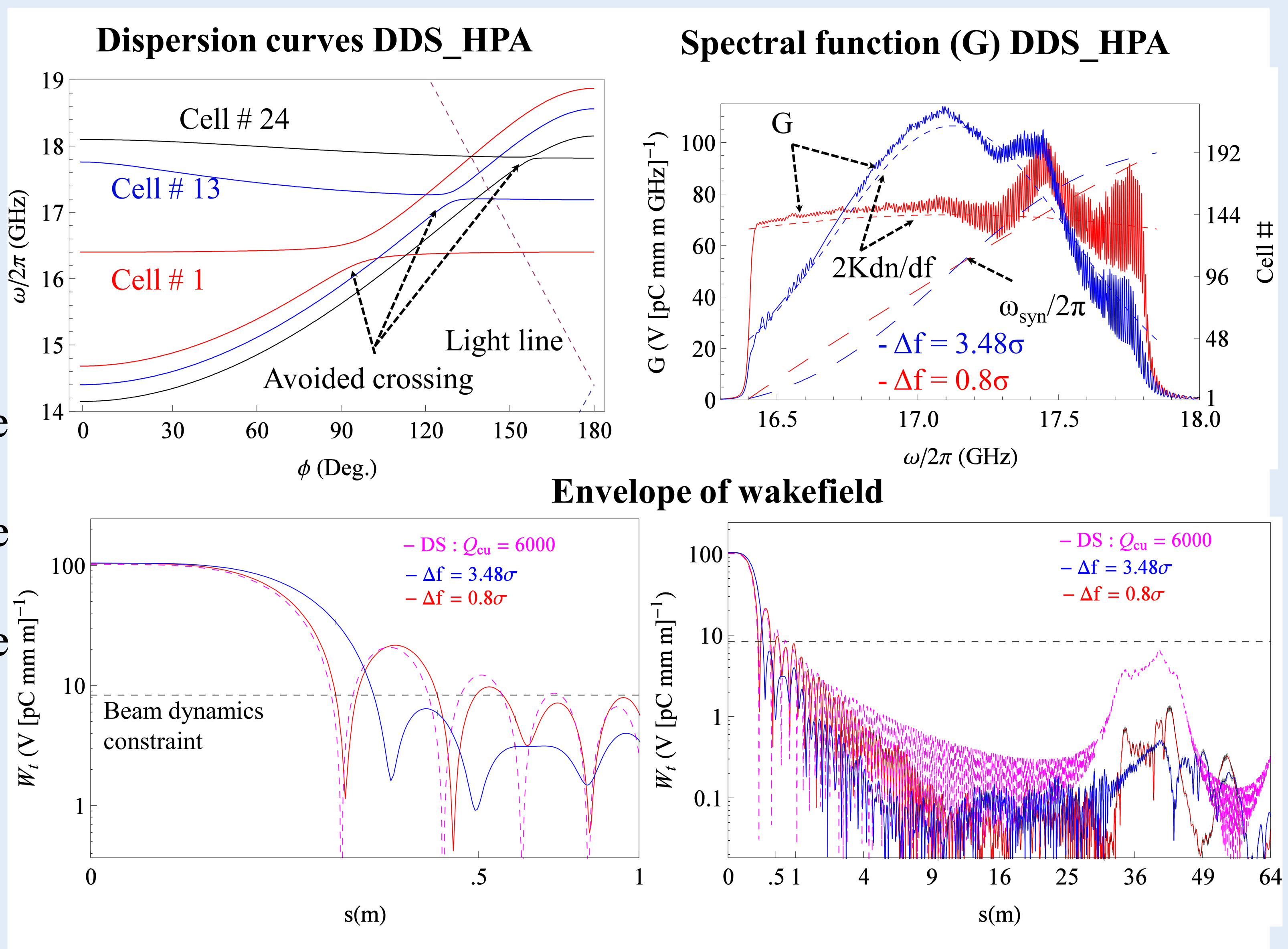
Synchronous kick factors



Kick	ϕ_{acc}		Δ
kV/pc/mm/m	2π/3	5π/6	%
ΣK_1	1.93	1.49	23
ΣK_3	0.42	0.6	-44
ΣK_6	0.38	0.24	37
ΣK_{1+3+6}	2.73	2.32	15

SUPPRESSION OF FIRST DIPOLE BAND COMPONENT OF WAKEFIELD

- Spectral function [2] for a Gaussian distribution with a bandwidth $\Delta f = 3.48\ \sigma$, together with $\Delta f = 0.8\ \sigma$ is illustrated to the right. In addition, the corresponding synchronous frequency and kick factor weighted density functions are shown.
- Provided the $\Delta f = 0.8\ \sigma$ distribution is used, together with a reduced bunch population ($n_b = 3 \times 10^9$), the wakefield satisfies the beam dynamics constraints (minimal emittance dilution).



CONCLUSION

- HPA operation benefits from a reduced group velocity of the accelerating mode (alleviates breakdown and allows for further optimisation).
- The enhanced damping of the lowest dipole mode (compared to standard phase advance) will ensure beam stability.
- Further enhancement of the damping of the lowest dipole mode in HPA structure (additional manifolds and insertion of SiC) is in progress.

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REFERNCES

[1] H. Braun, *et. al*, CLIC-Note764, 2008.
[2] R.M. Jones, *et. al*, PRST-AB, **9**, 102001, 2006.
[3] R.M. Jones, PRST-AB, **12**, 104801, 2009.
[4] V.F. Khan, *et. al*, LINAC10, 2010..
[5] V.F. Khan, *et. al*, IPAC10, 2010
[6] B. Zotter and K. Bane, CERN ISR-TH/80-25, 1980.