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HG two-beam wake field accelerator using a two-channel rectangular dielectric structure*

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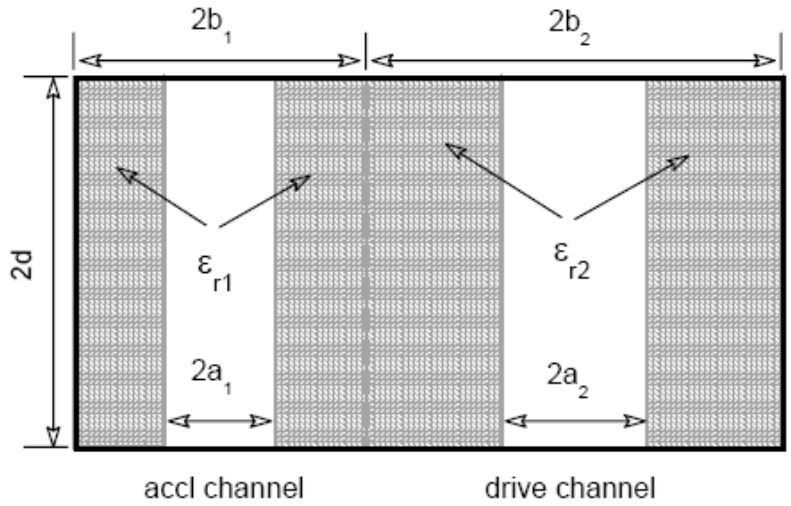
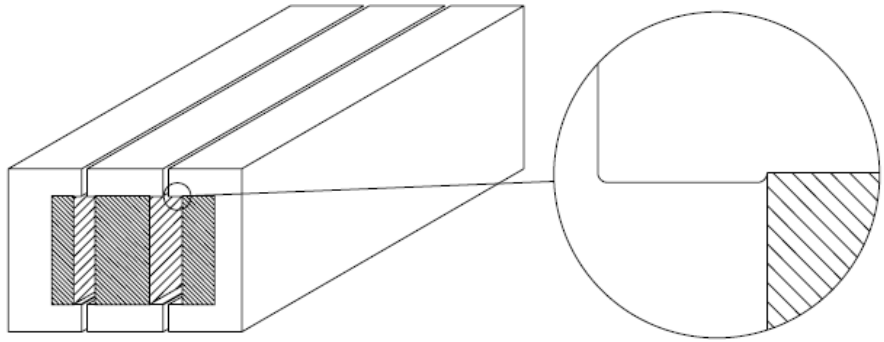


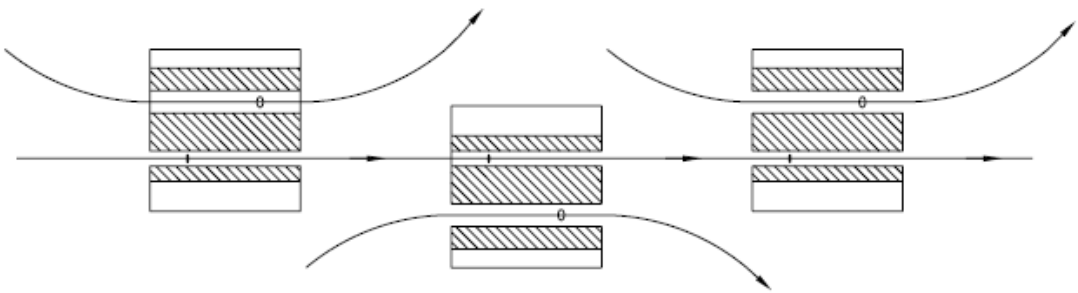
Features of a two-beam dielectric wake field accelerator (DWFA):

- High adjustable transformer ratio $T >> 2$;
- Wall slots and bunch location that may help suppress HOM's;
- Simple but precise fabrication of planar dielectric elements;
- Continuous coupling of energy from drive to accelerated bunch;
- No need for coupling/transfer structures;
- Continuous pumpout of narrow channels through wall slots;
- High accelerating fields in the single bunch mode.

Configuration for two-beam DWFA structure:

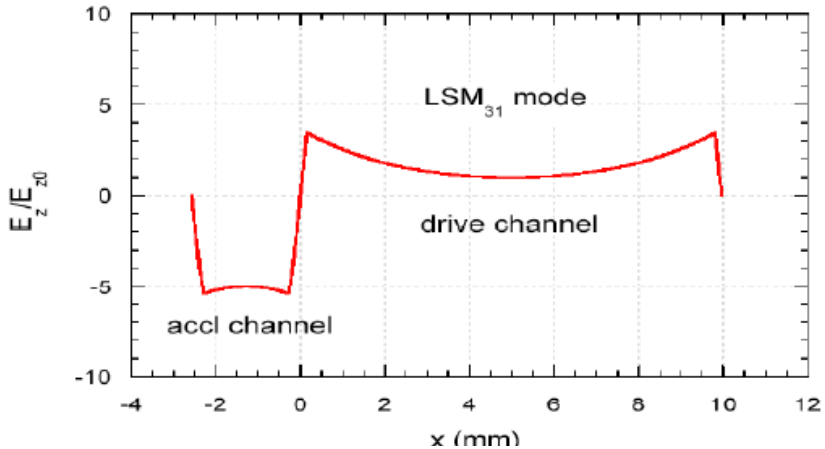


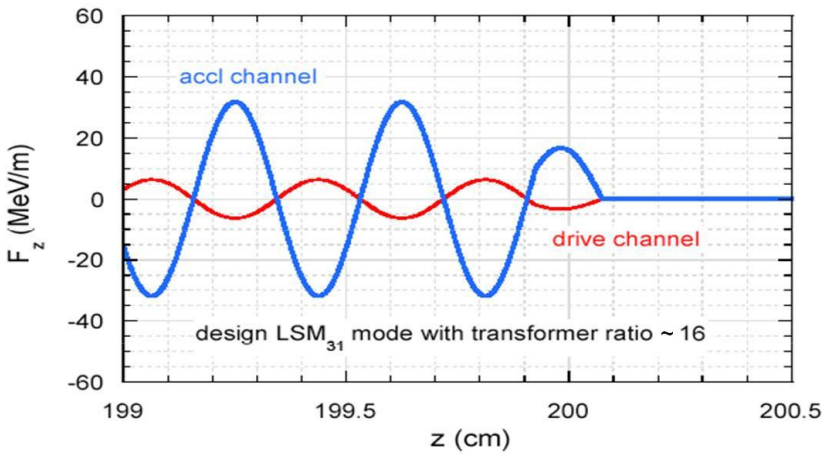
Possible multi-module arrangement that allows injection and extraction of drive bunches, where alternating orientation may help compensate transverse deflections for accelerated bunches:

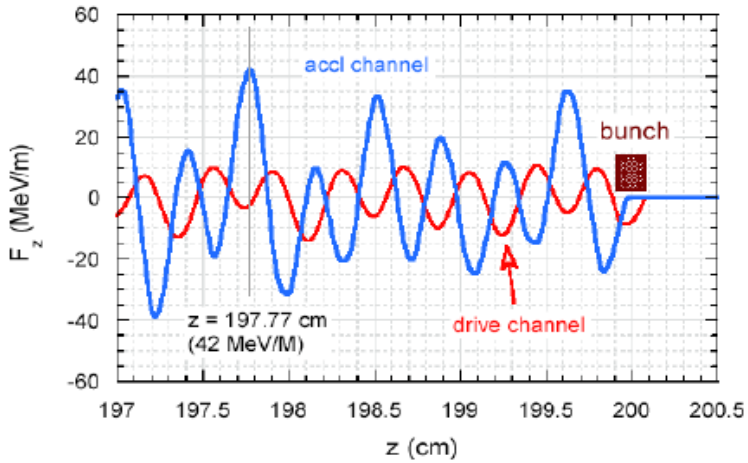


Illustrative example:

LSM_{31} design mode eigenfrequency	80.0 GHz
accelerating channel width $2a_1$	2.00 mm
drive channel width $2a_2$	9.64 mm
structure height $2d$	8.0 mm
peak field ratio, accel-to-drive channels	5.0
transformer ratio	~16:1
thickness of dielectric slab #1	0.28 mm
thickness of dielectric slab #2	0.44 mm
thickness of dielectric slab #3	0.16 mm
relative dielectric constant (macor)	5.7
bunch size (x,y,z)	1.8 mm × 1.8 mm × 1.5 mm
bunch energy	14 MeV
bunch charge	50 nC
bunch charge density	10.3 nC/mm^3
bunch number	1

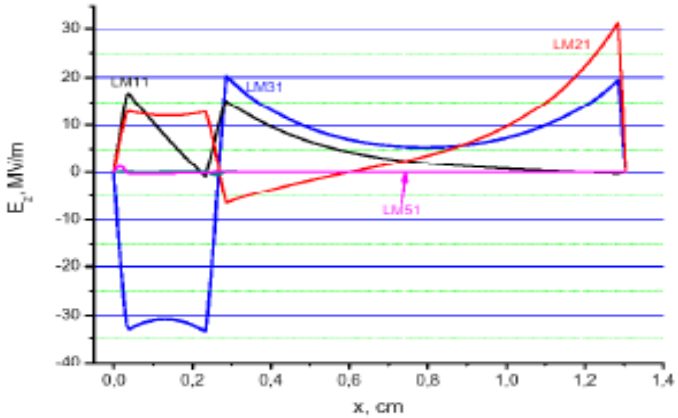


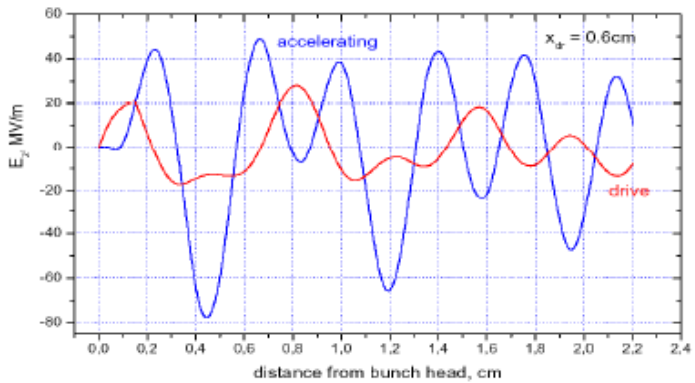




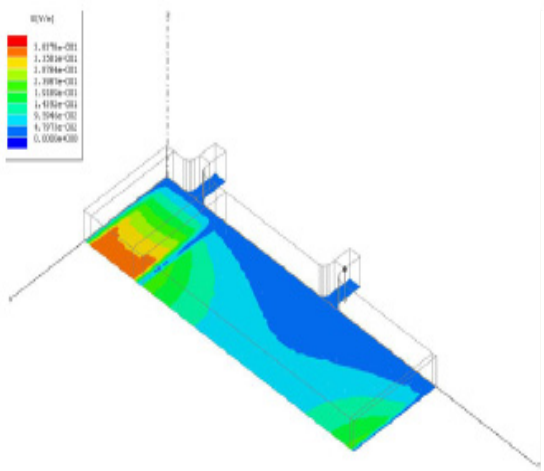
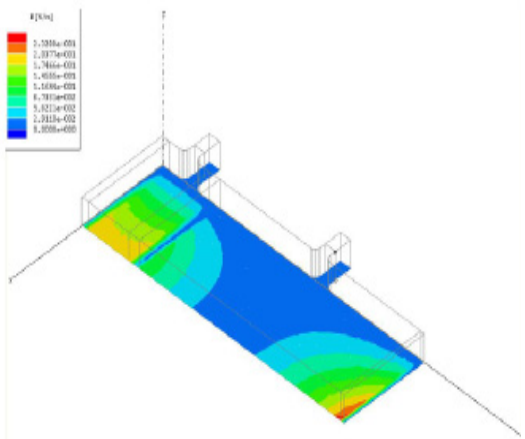
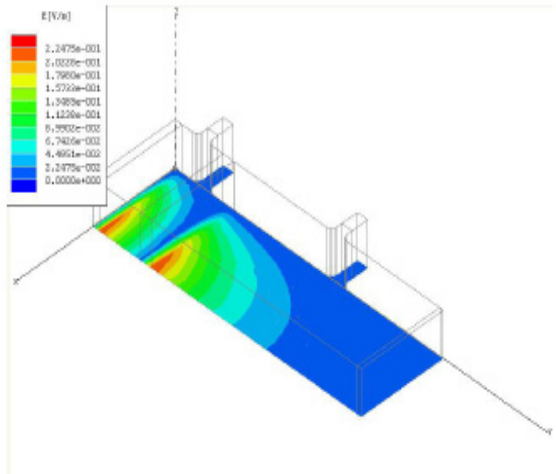
Proposed collaborative experiment with Argonne National Laboratory Wake Field Accelerator Group

LSM_{31} design mode eigenfrequency	80.003 GHz
accelerating channel width $2a_1$	2.0 mm
drive channel width $2a_2$	10.0 mm
structure height $2d$	8.0 mm
peak field ratio, accel-to-drive channels	5.73
transformer ratio	~8:1
thickness of dielectric slab #1	0.343 mm
thickness of dielectric slab #2	0.513 mm
thickness of dielectric slab #3	0.181 mm
relative dielectric constant (at 80 GHz)	4.0
bunch size (x,y,z)	1.8 mm × 1.8 mm × 1.5 mm
bunch energy	14 MeV
bunch charge	50 nC
bunch charge density	10.3 nC/mm^3
bunch number	1





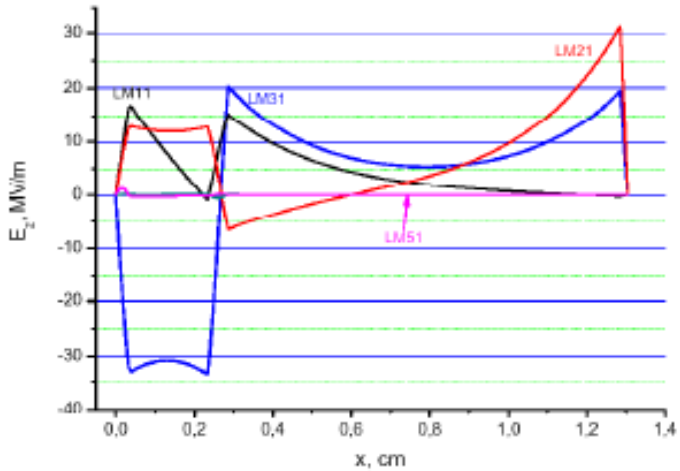
Damping of HOM's from wall slots*

LSM_{31}	LSM_{21}	LSM_{11}
		
f_o = 79.912 GHz	f_o = 79.682 GHz	f_o = 45.620 GHz
Q_o = 4000	Q_o = 8000	Q_o = 5000
f = 79.911 GHz	f = 79.660 GHz	f = 45.340 GHz
Q = 3200	Q = 2800	Q = 175

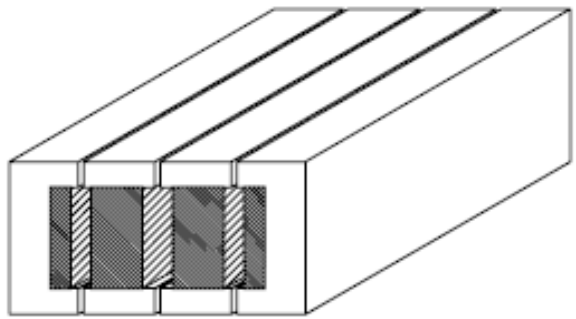
*For these simulations, loss tangent for Cordierite is taken to be 1.5×10^{-3}.

Further means for countering beam deflections due to both short- and long-range transverse wakes

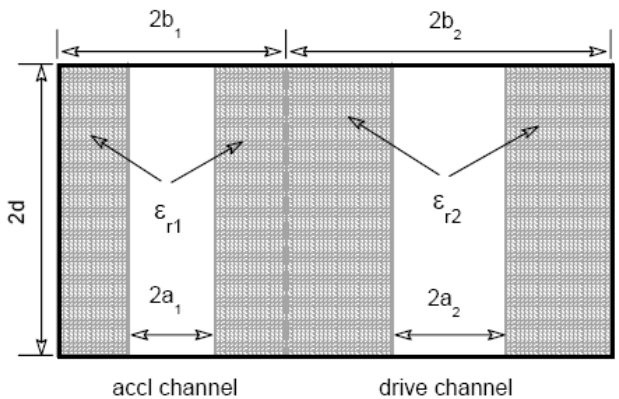
a. Insert drive bunch off-axis, to minimize excitation of LSM_{21} (dipole-like) mode.



b. Symmetrize the structure. (3-beams!)

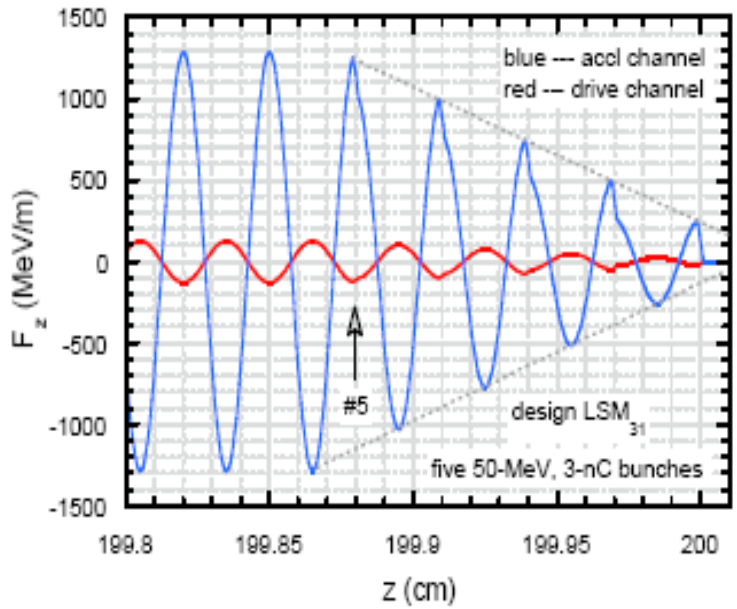


c. Symmetrize the fields in the channels using $\varepsilon_1 \neq \varepsilon_2$.



Super-HG THz-scale two-channel DWFA

frequency of LSM_{31} operating mode	1000 GHz
accl channel dimensions $2a_1 \times 2b_1$	0.1 mm × 0.153 mm
drive channel dimensions $2a_2 \times 2b_2$	0.958 mm × 0.984 mm
structure width $2(b_1+b_2)$	1.137 mm
structure height $2d$	0.6 mm
transformer ratio	~13:1 (3rd bunch)
slab-1 thickness (b_1-a_1)	0.027 mm
slab-2 thickness $(b_1-a_1)+(b_2-a_2)$	0.040 mm
slab-3 thickness (b_2-a_2)	0.013 mm
slab relative dielectric constant ε	5.7
bunch size	$0.3 \times 0.3 \times 0.02$ mm^3
bunch charge	3 nC
bunch number	5



SUMMARY AND CONCLUSIONS

Rectangular geometry for a two-beam, two-channel, dielectric wake field accelerator has several unique virtues, including:

1. high transformer ratio ($T > 10$);
2. high acceleration gradient, even in the single-bunch mode;
3. precise fabrication and uniformity for dielectric slabs;
4. no transfer/coupling structures between channels needed;
5. axial slots for pumping of both channels; and
6. suppression of transverse wake fields by axial slots and other symmetrizing strategems.

A proof-of-principle experiment at ANL is planned.