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A Fast Kicker Using a Rectangular Dielectric Wakefield Accelerator Structure*

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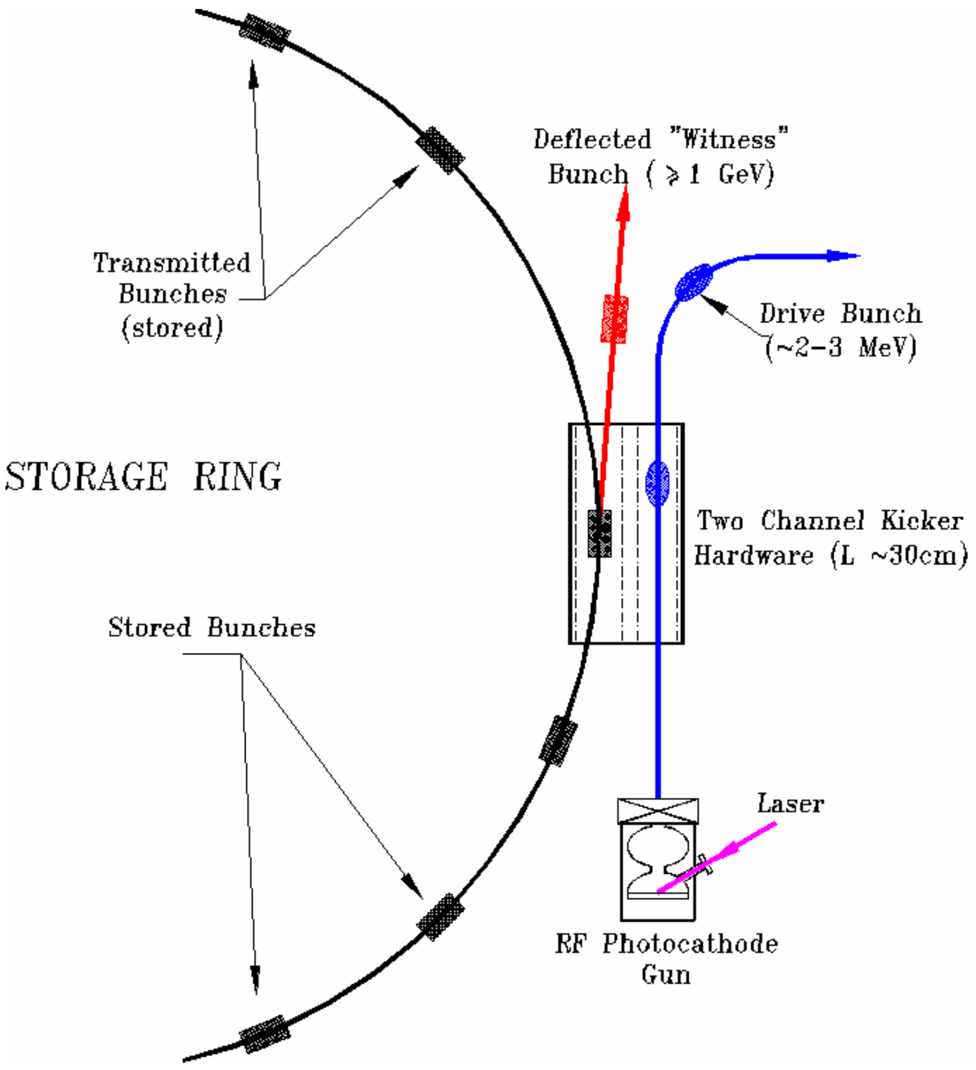
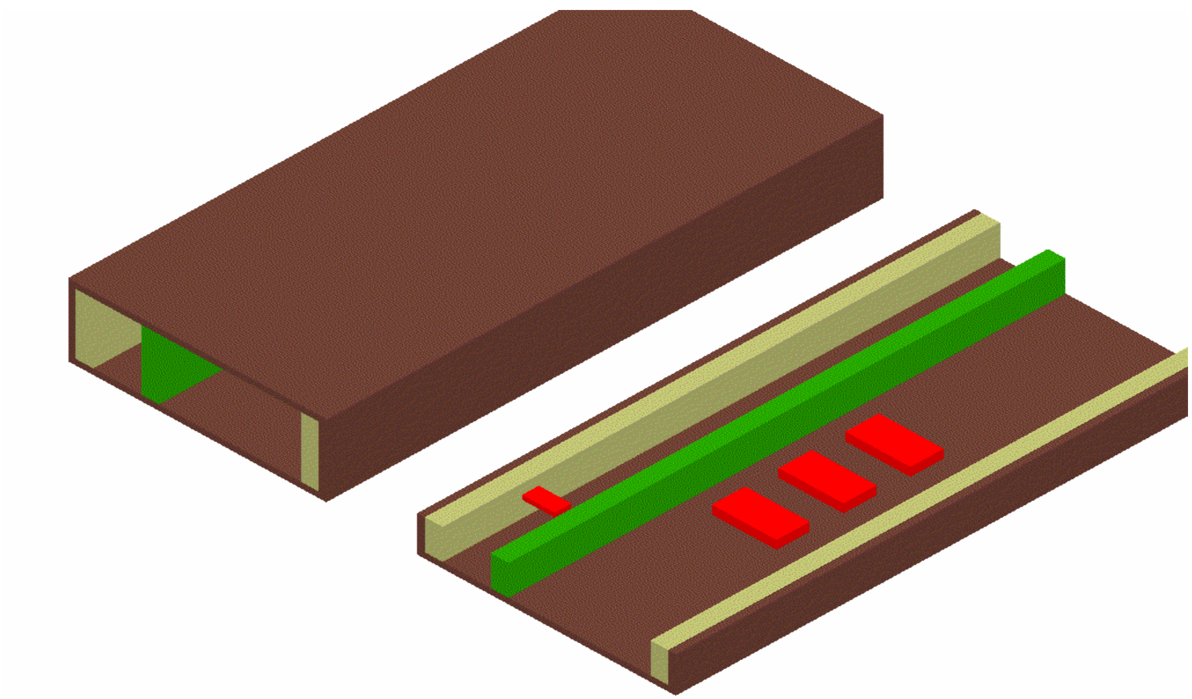
Schematic of the fast kicker concept

Not drawn to scale



A rectangular two-beam dielectric wakefield accelerator (DWFA) is under study in a collaboration between Omega-P, Yale, Columbia, and ANL. Due to asymmetry, this stucture will deflect a test bunch moving in the narrow channel, due to wake fields set up by drive bunches in the broad channel.

Schematic of two-channel rectangular DWFA



Cross section of DWFA built for experiments at ANL-AWA

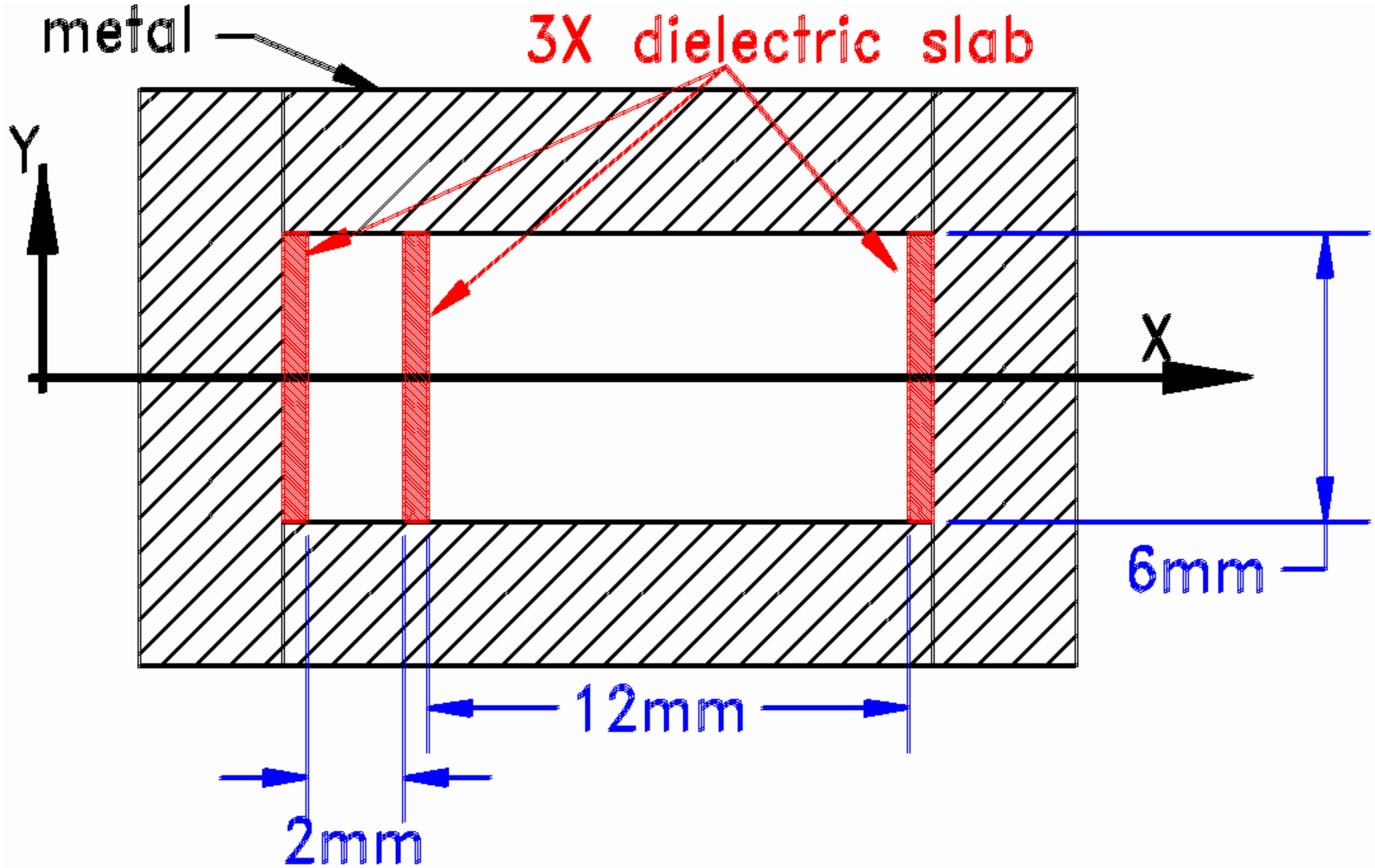


Table I: Parameters of DWA unit to be tested at AWA.

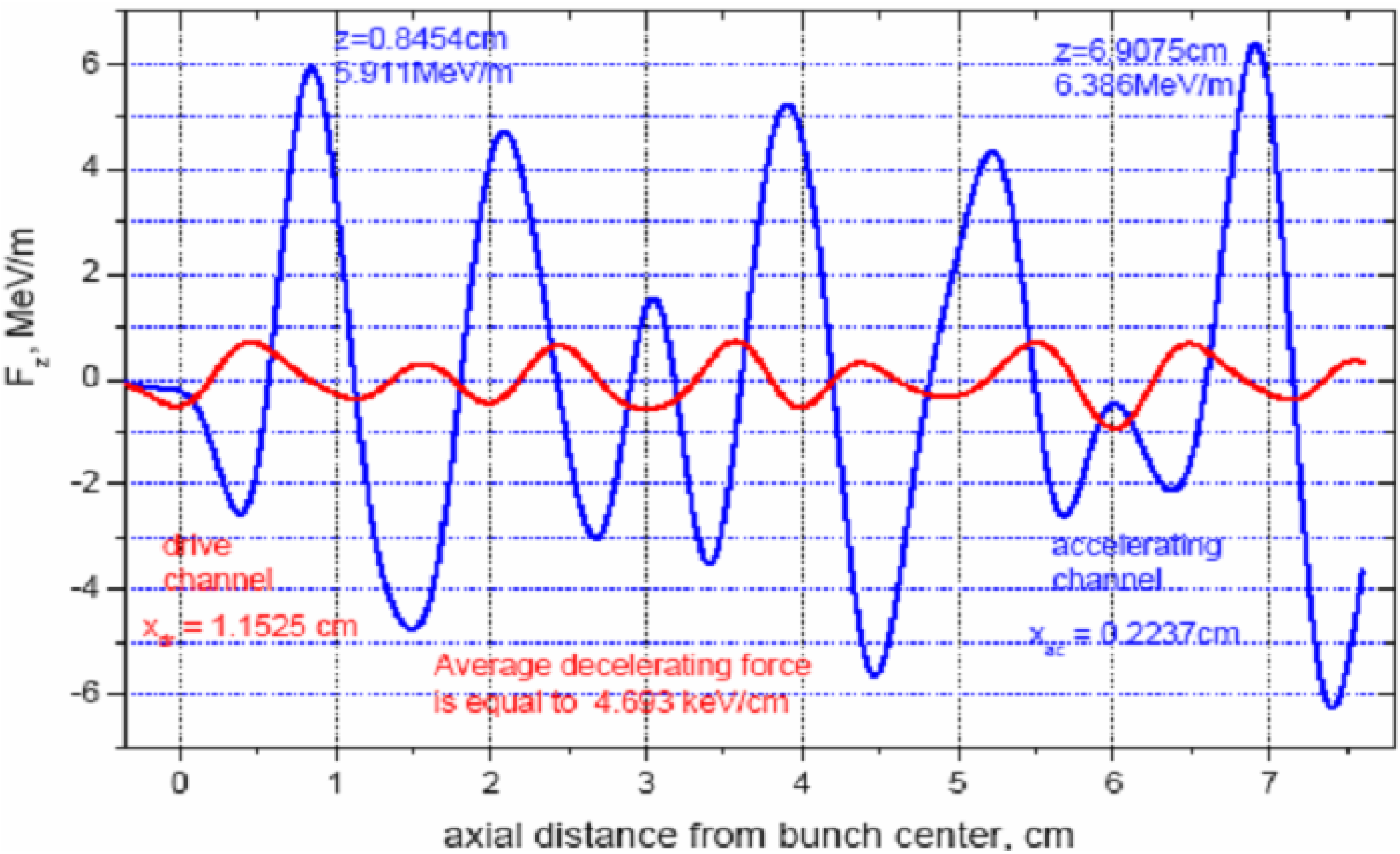
LSM_{31} design mode	29.965 GHz
Accl. channel width	2.0 mm
drive channel width	12 mm
structure height	6.0 mm
slab-1 thickness	1.237 mm
slab-2 thickness	2.288 mm
slab-3 thickness	1.051 mm
slab relative dielectric constant	4.76
drive bunch RMS dimensions, $2\sigma_x \times 2\sigma_y \times 2\sigma_z$	6.0x2.0x4.0 mm^3
drive bunch energy	14 MeV
drive bunch charge	50 nC

Axial component of wakefield due to one drive bunch

Note: 50-nC drive bunch is at $z = 0^-$, moving to the left.

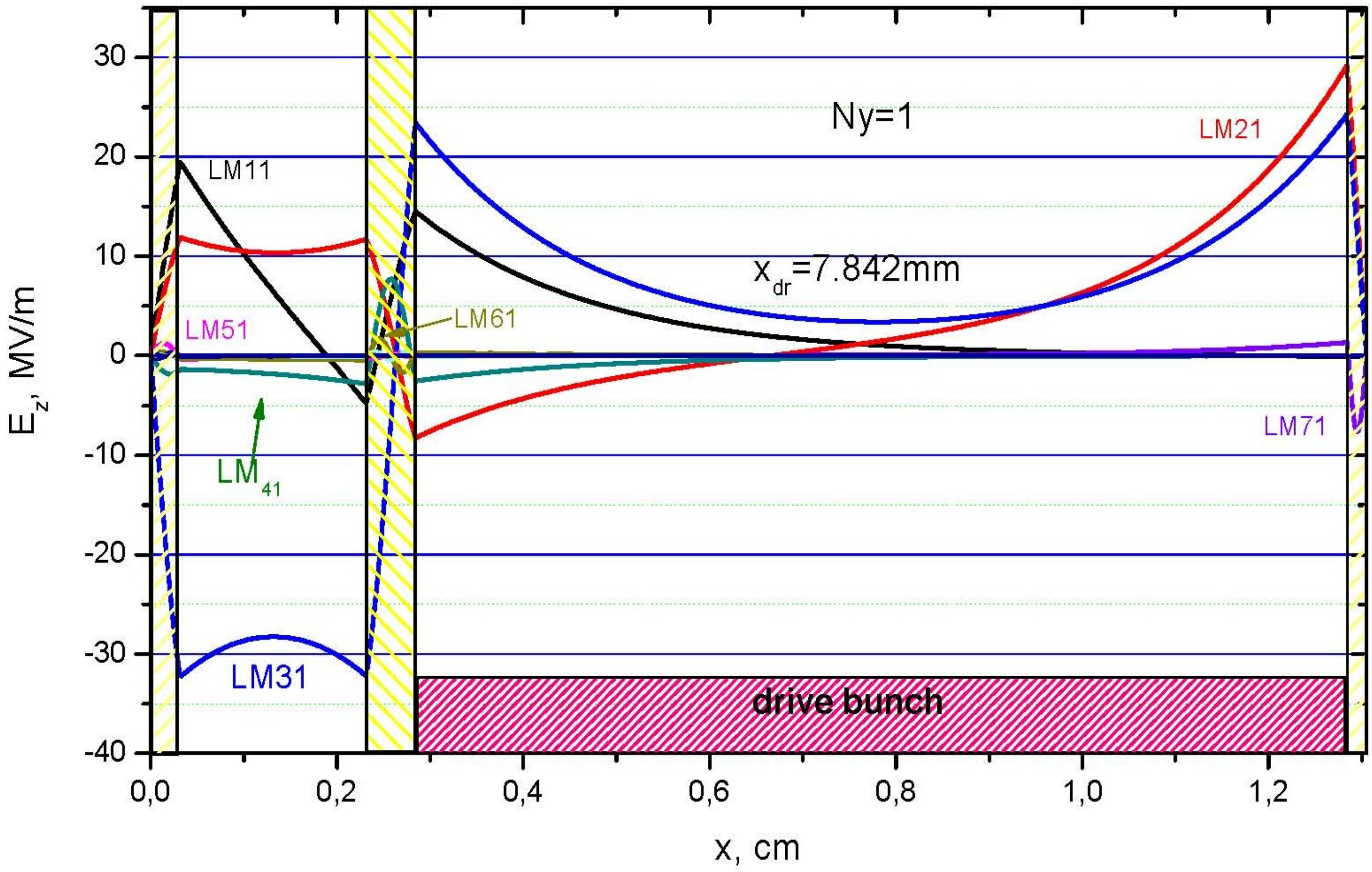
*E_z field in drive channel is in **red**, and in accel channel is in **blue**.*

At first accelerating peak (0.85 cm), T = 12.6.



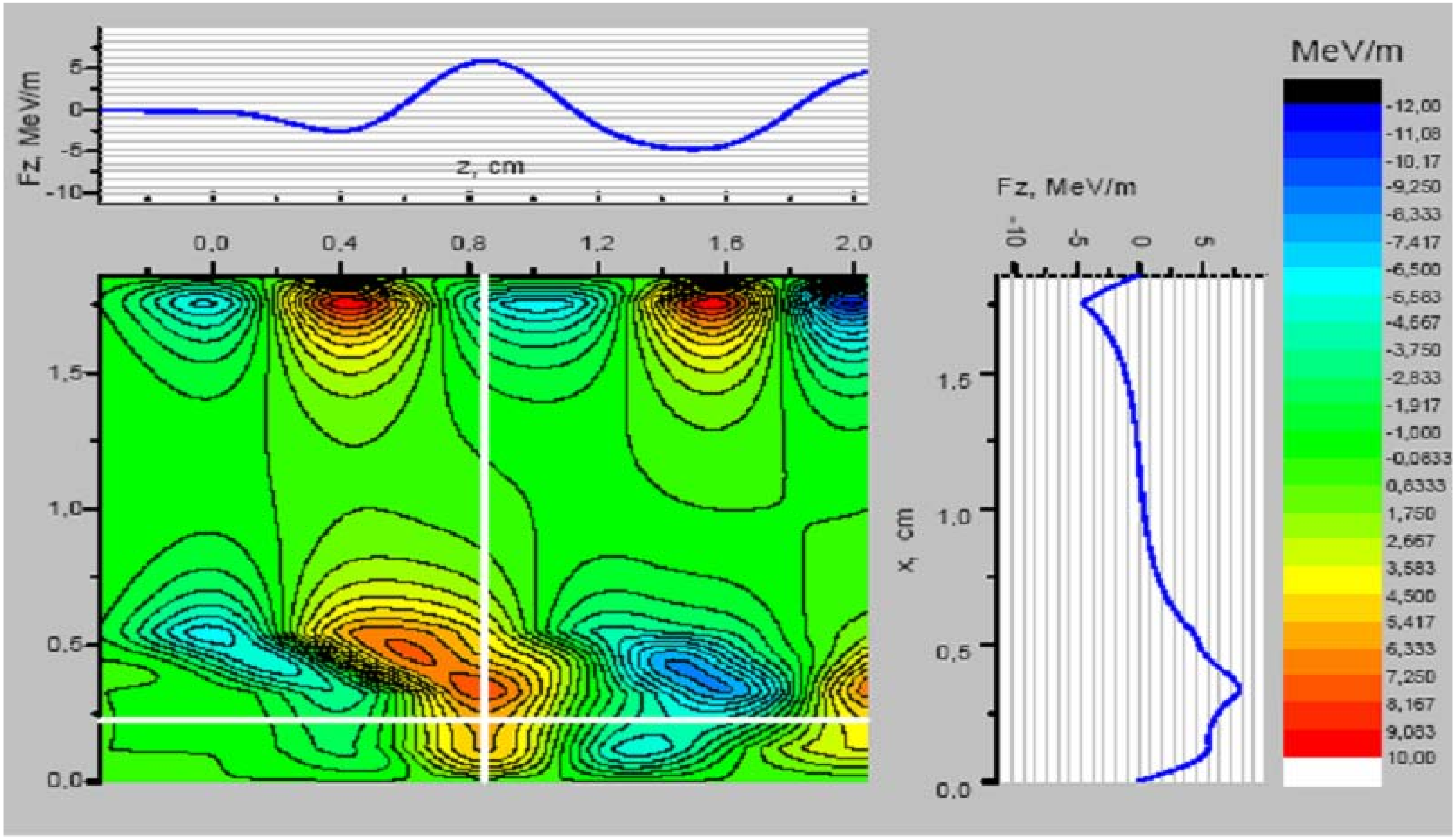
Transverse profiles of modes

"Design" mode is LM31, but simultaneous excitation of LM21 (and others) is inevitable.



Map of axial force in the *x-z* plane

Asymmetry is self-evident.



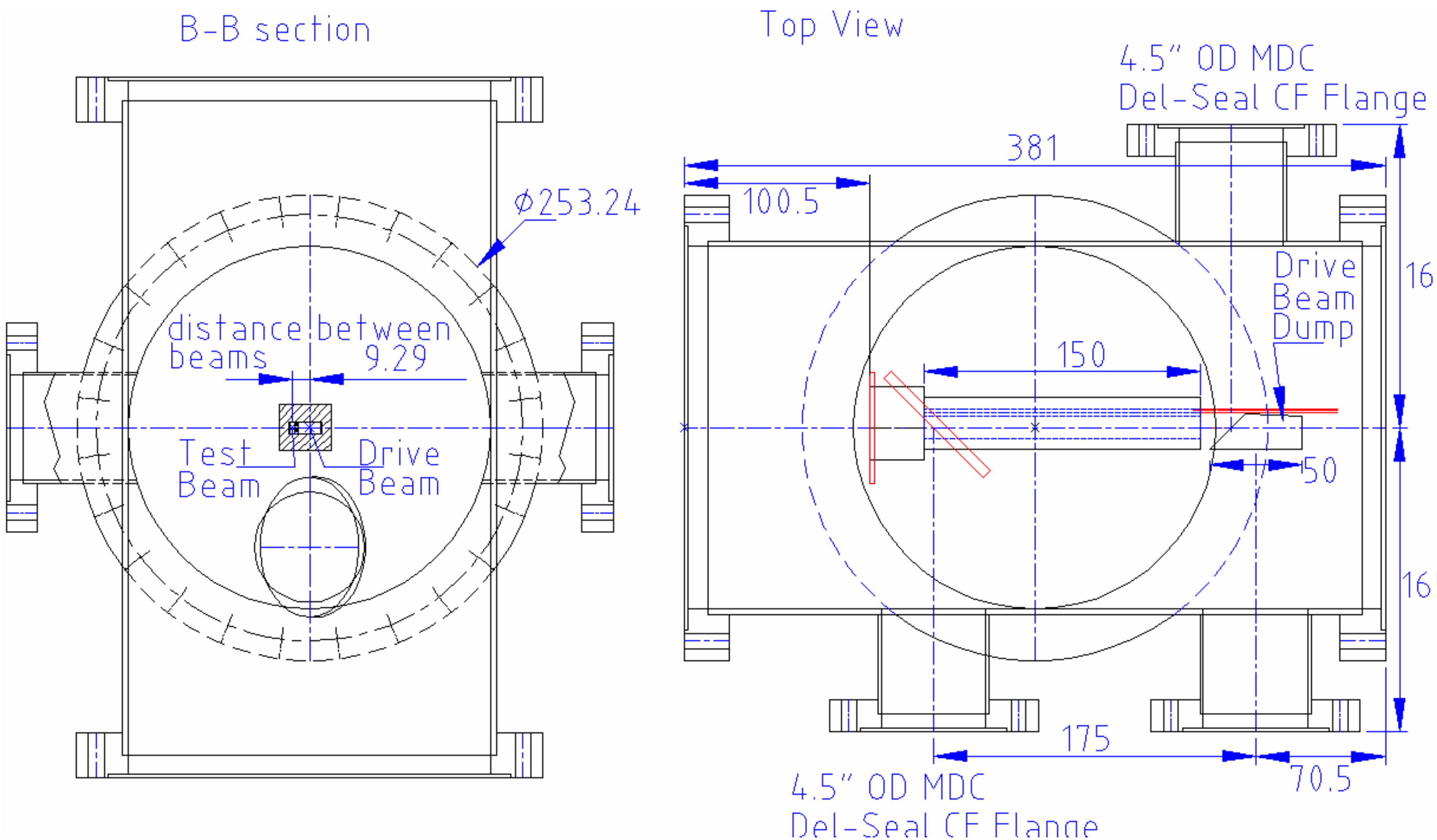
First objective for experiments at ANL-AWA: to test the two-channel DWFA structure, and to compare results with theoretical predictions.

(Kicker experiments will follow, pending DoE approval.)

- What will be measured: energy gain of witness bunch electrons, and microwave radiation spectrum of drive bunch.
- Double-pulse rf photocathode is expected to generate a timed, delayed test bunch.
- Two channels are expected to provide a high transformer ratio.
- Dielectric is Cordierite, $\varepsilon = 4.76$.

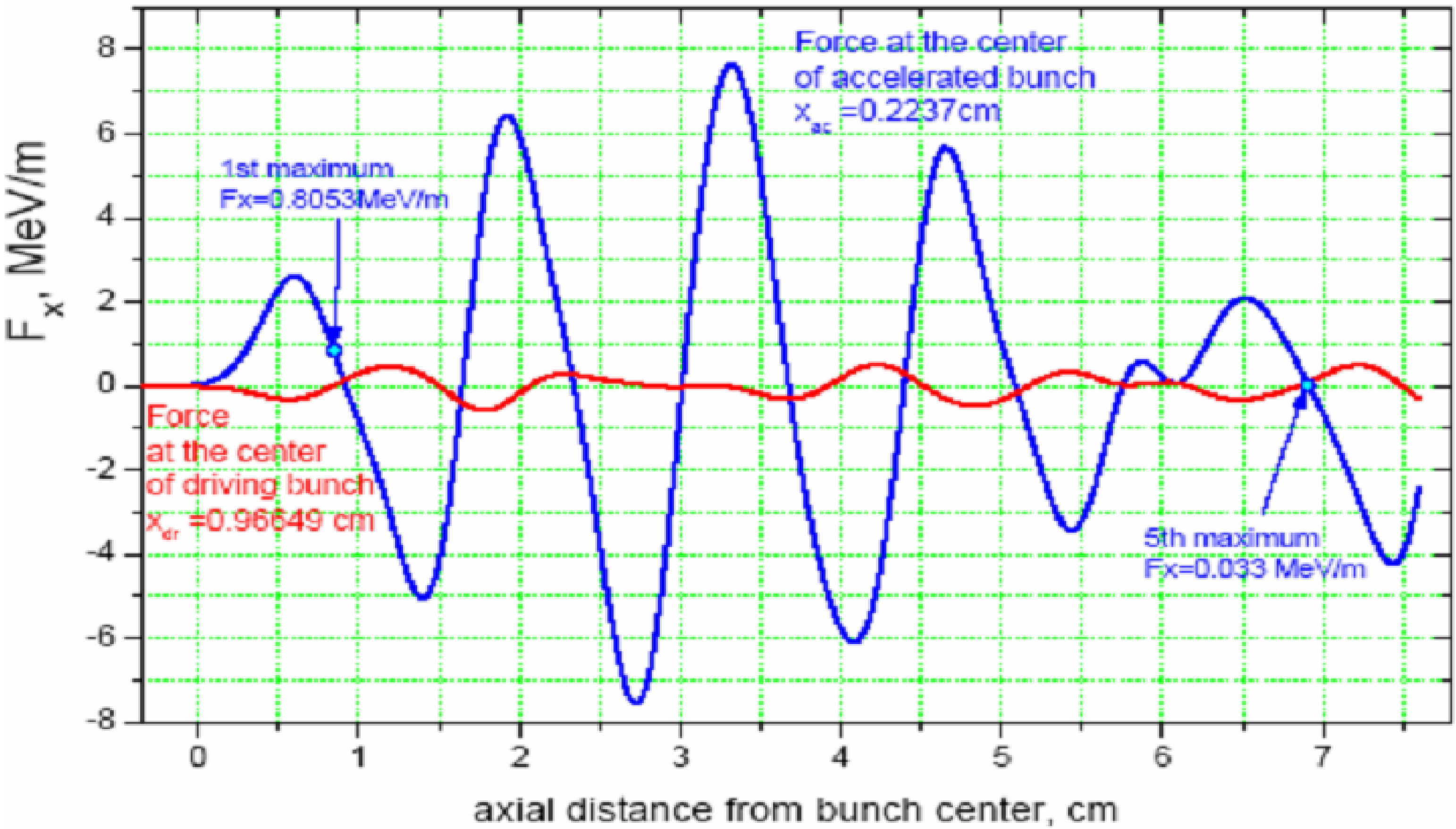
Apparatus to be installed and operated on ANL-AWA beamline

in collaboration with W. Gai, J. Power, and M. Conde of ANL.



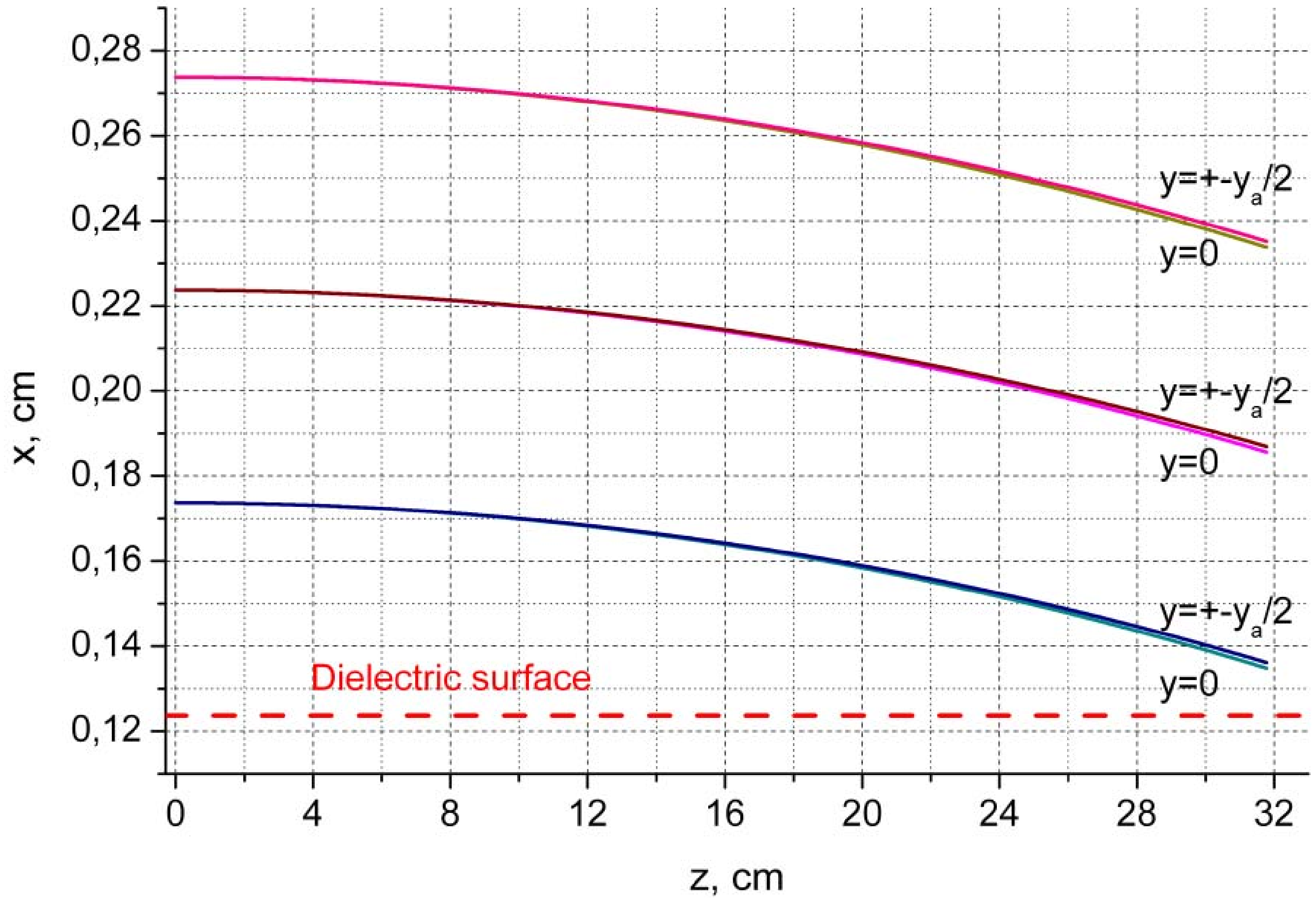
Now, what about "kicking?"

Plot shows deflecting F_x-force vs. z in the accelerating channel.



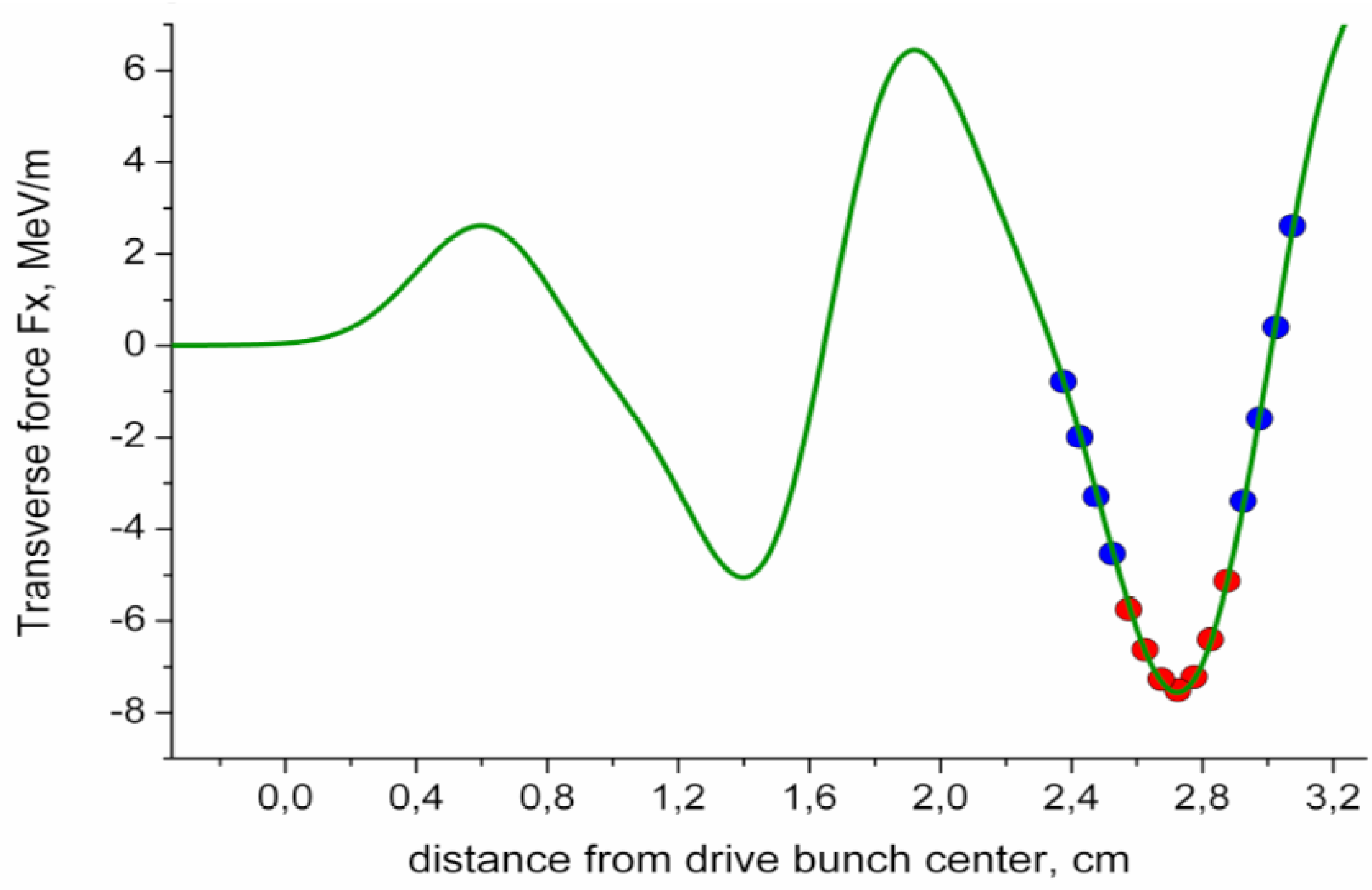
Calculated *x*-component of transverse deflection of nine 1-GeV test particles in a 30-cm long two-channel rectangular test module

x deflection is ~ 0.4 mm in 300 mm, or 1.3mrad



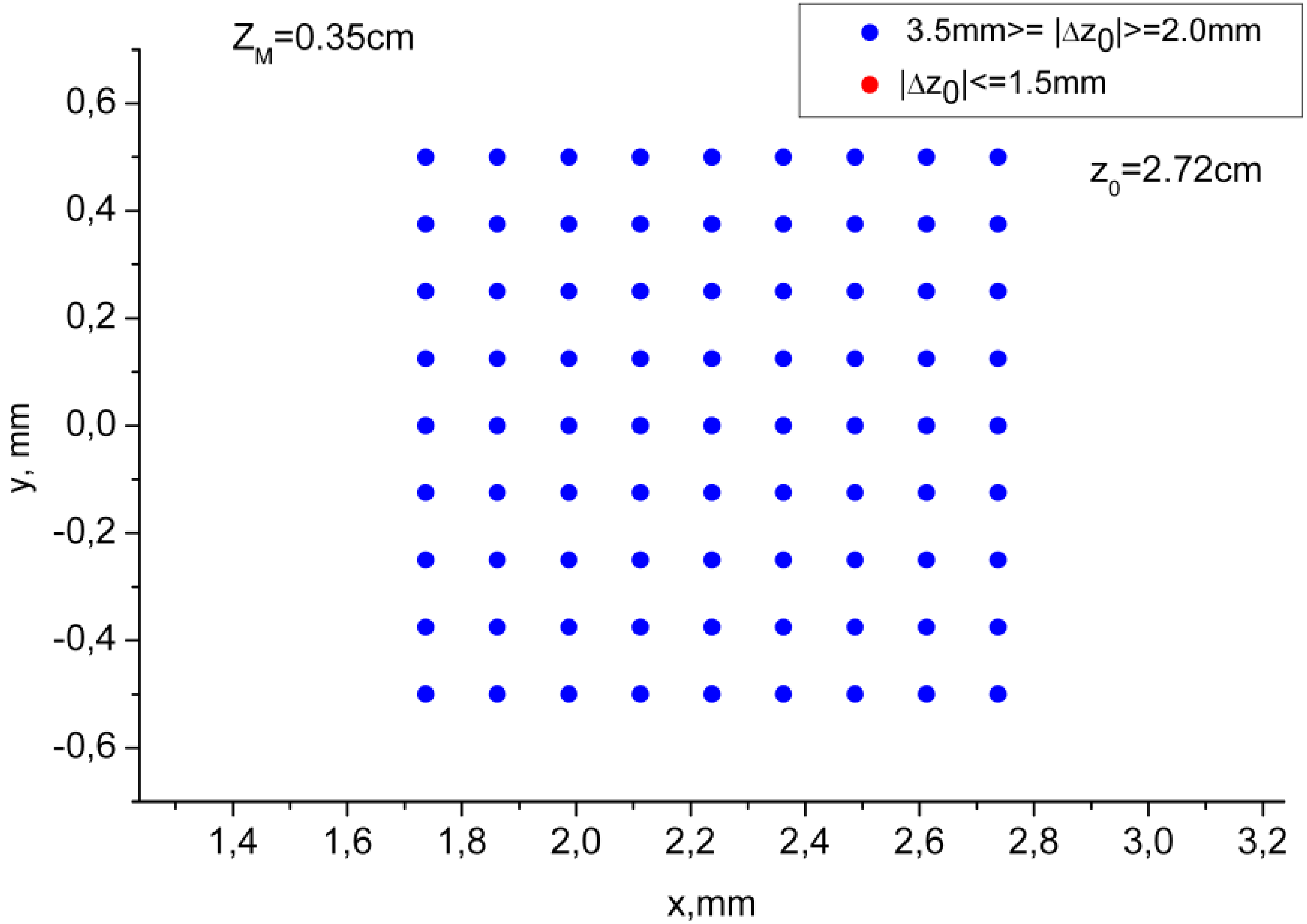
Dots represent axial locations of rows of test particles for beam portraits to be shown in the following slides.

*Note axial locations of **red** and **blue** particles.*



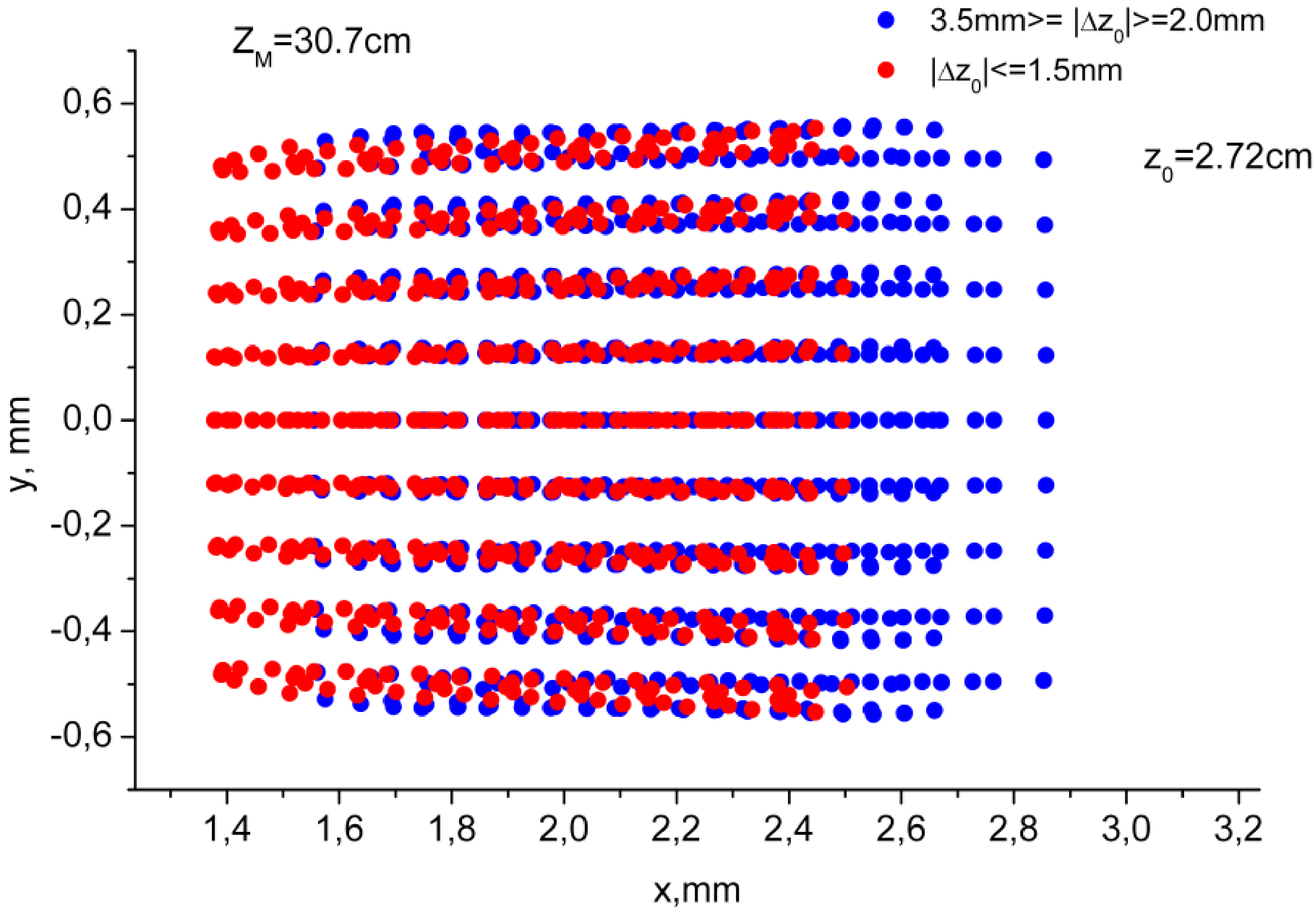
Portrait of test particles at initial transverse locations in the witness channel at input to structure.

Note: red particles are hidden behind blue particles.



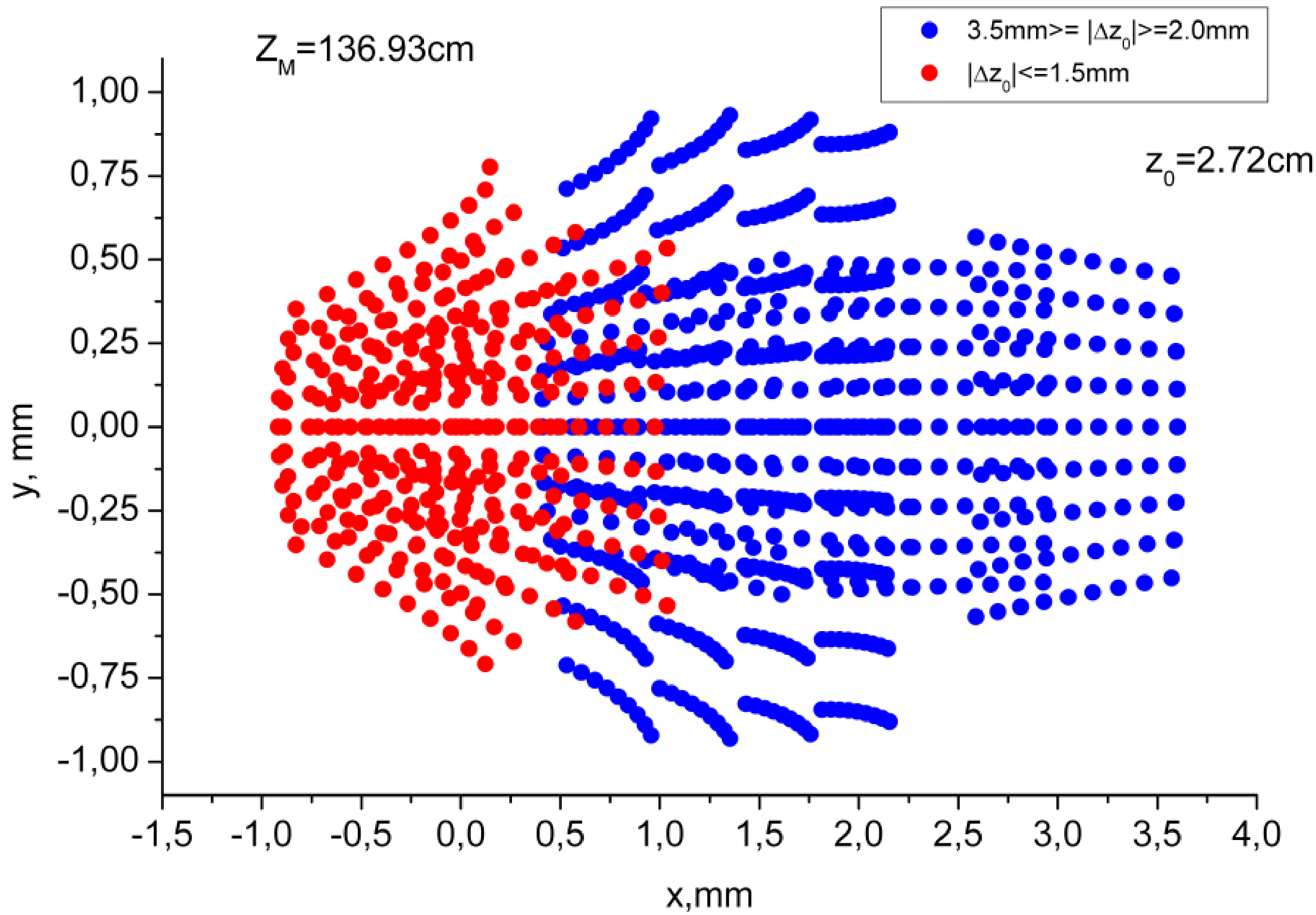
Portrait of test particles in the witness channel at the end of the 30 cm-long structure.

Note that particles in a 3-mm slug at center of bunch are deflected much more than particles at leading and trailing edges of bunch.

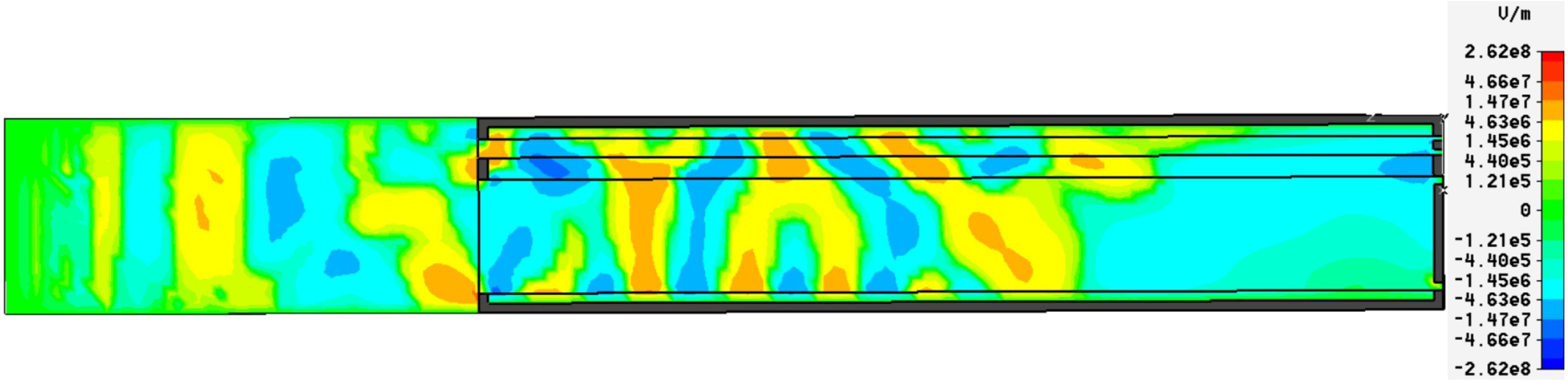


Portrait of witness test particles after travelling an additional 1 m beyond the structure.

Note the clear separation of red and blue particles, and the vertical (*y*) focusing.

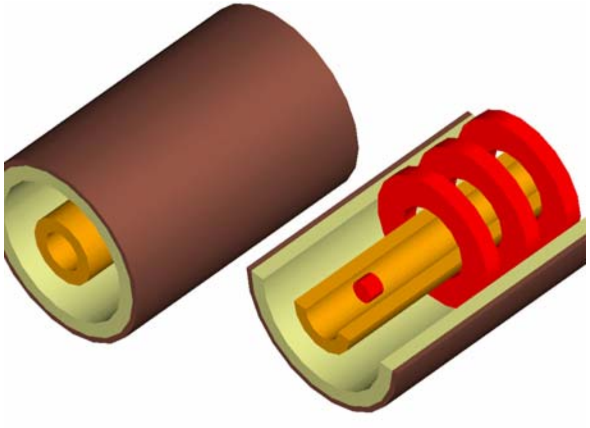


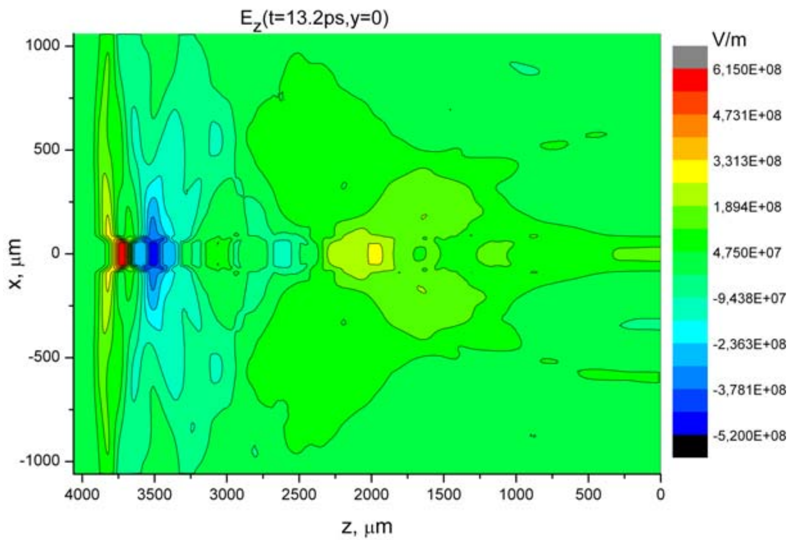
In contrast to RF cavity fields, wakefields are removed rapidly (~1 nsec) from the structure, so a following bunch is not deflected if there is no preceding drive bunch.

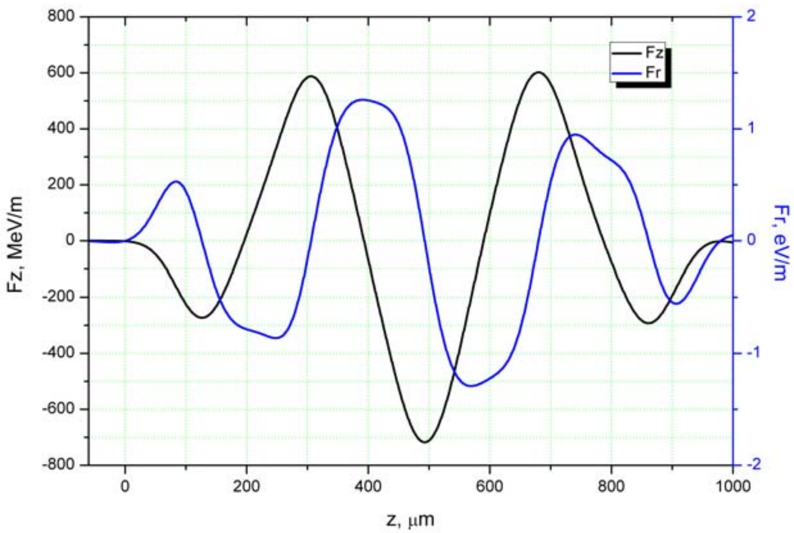


BUT NOT ALL DIELECTRIC-LINED STRUCTURES IMPOSE KICKS: CONSIDER A COAX STRUCTURE.

Sotnikov et al (this meeting) show computed fields in a mm-scale coaxial DWFA set up by a single 6-nC, 5-GeV annular drive bunch.







SUMMARY

- Structure design to maximize the deflecting force has not been undertaken. The example shown is for an existing module built to test acceleration and to confirm high transformer ratio (>10:1).
- But preliminary estimates show that deflections large enough for single bunch selection can be produced using a non-symmetric dielectric-lined waveguide energized by a high-charge drive bunch.
- Conditions can also probably be found for selection of either a portion of a wide bunch, or a sequence of several bunches.
- If no drive bunch is injected, stored bunches (1-nC, 1-GeV, ~ 1-cm in the example) experience negligible self-induced wakefield forces.
- The drive bunch energy (14 MeV in the example) is not critical fo this kicker; a relativistic bunch provided from a single-cell RF photocathode gun will do, so long as its charge is some 10's of nC.
- The coaxial DWFA has good symmetry, and thus imposes no kicking. It appears to be a good candidate for a high-gradient accelerator.