Single Cycle THz Acceleration Structures

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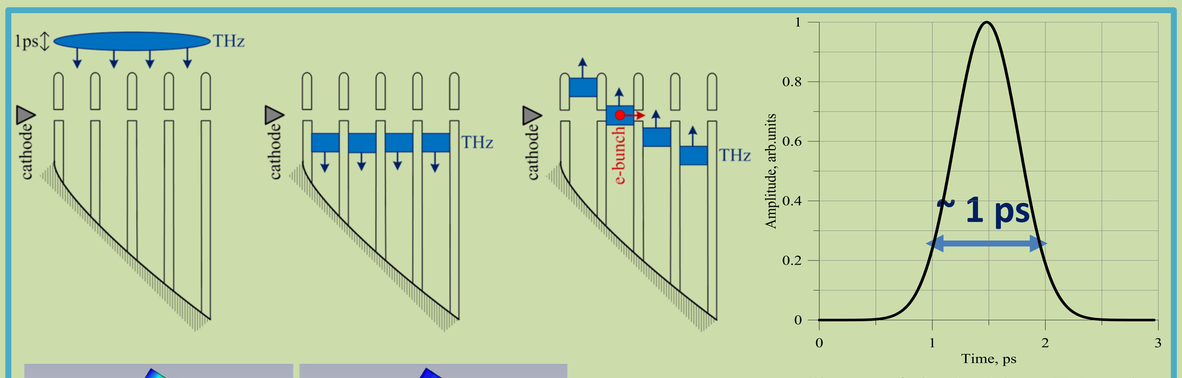
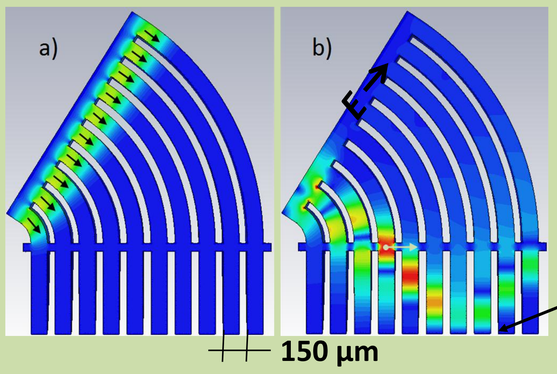
Introduction

Recently, gradients on the order of 1 GV/m level have been obtained in a form of single cycle (~1 ps) THz pulses produced by conversion of a high peak power laser radiation in nonlinear crystals (~1 mJ, 1 ps, up to 3% conversion efficiency). These pulses however are broadband (0.1-5 THz) and therefore a new accelerating structure type is required. For electron beam acceleration with such pulses we propose arrays of parabolic focusing micro-mirrors with common central. These novel structures could be produced by a femtosecond laser ablation system developed at Euclid Techlabs. This technology had already been tested for production of several millimeters long, multi-cell structure which has been testing with electron beam. We also propose using of structures where necessary GV/m E-fields are excited by a drive bunch travelling in the corrugated waveguide. The radiated by drive bunch sequence of short range delayed wakes are guided in this case by metallic disks and reflected back being focused exactly at time when the witness bunch arrives.

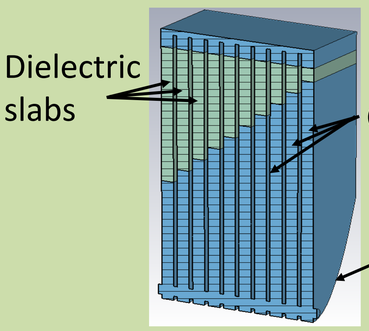


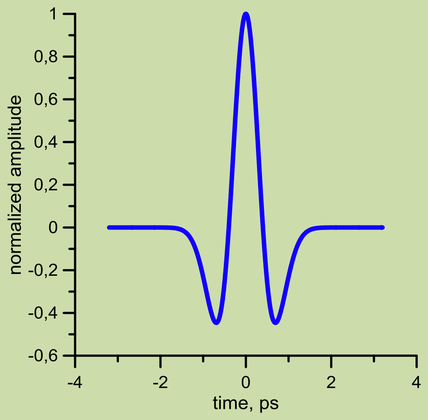
Shape of the incident THz pulse

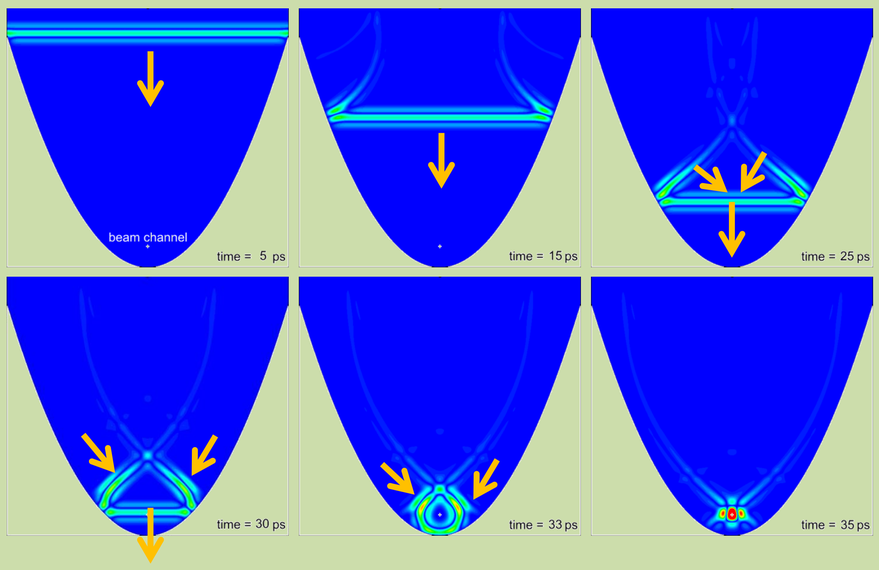


Gained energy – 0.4 MeV ,
Gradient is 0.3 GV/m.
(for 1 mJ pulse of 1 ps THz pulse)

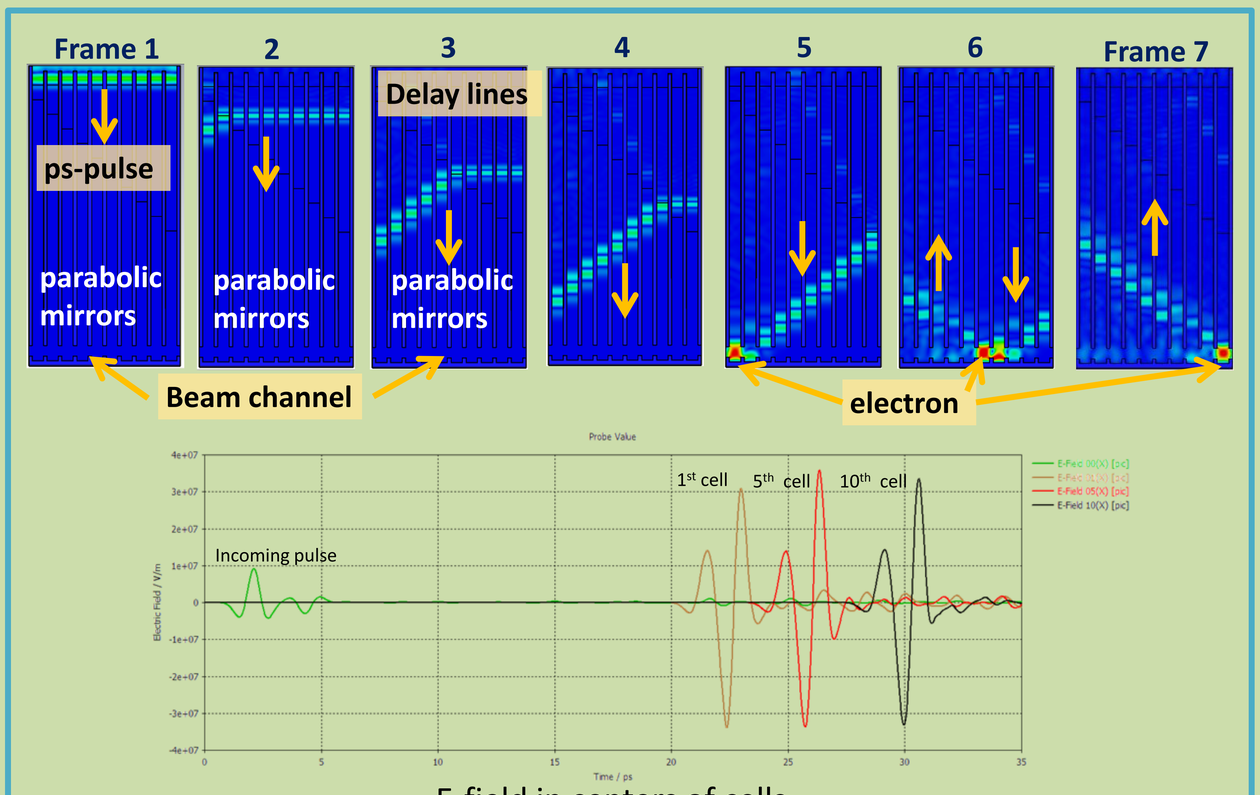
Focusing parabolic mirrors



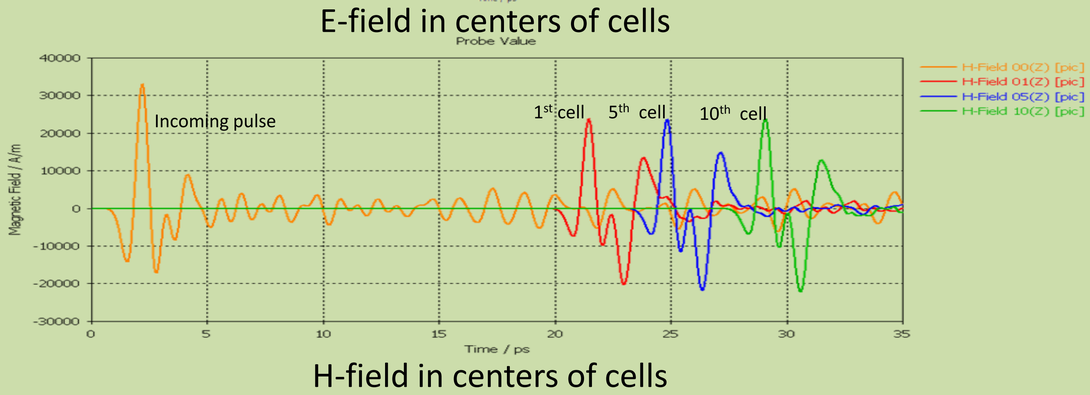




Field distributions at the parabolic mirror while focusing the short THz pulse, for six sequential instants in time.

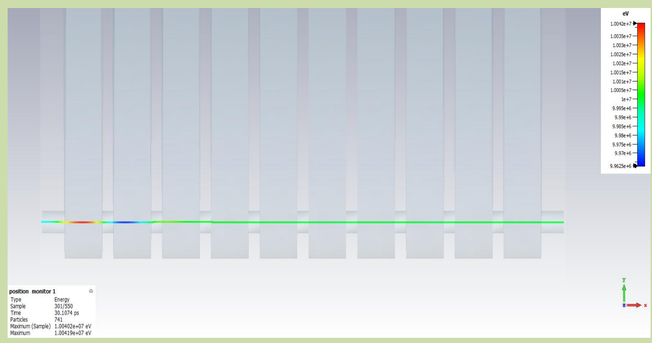


E-field in centers of cells

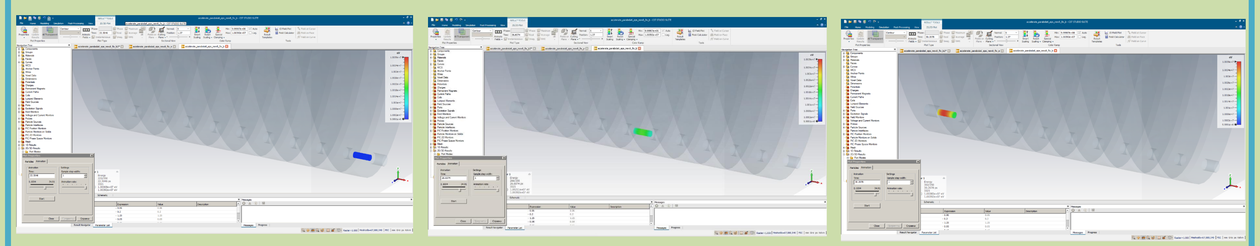


H-field in centers of cells

Parameters	
THz pulse duration	1 ps
Period	260 μm
Wall thickness	60 μm
Beam hole diameter	100 μm
Aperture	2.5 mm
Focus strength	160 μm
Length (10 cells)	2.6 mm
Dielectric permittivity (quartz)	3.75
Dielectric length icrement	278 μm



Acceleration of CW electron beam



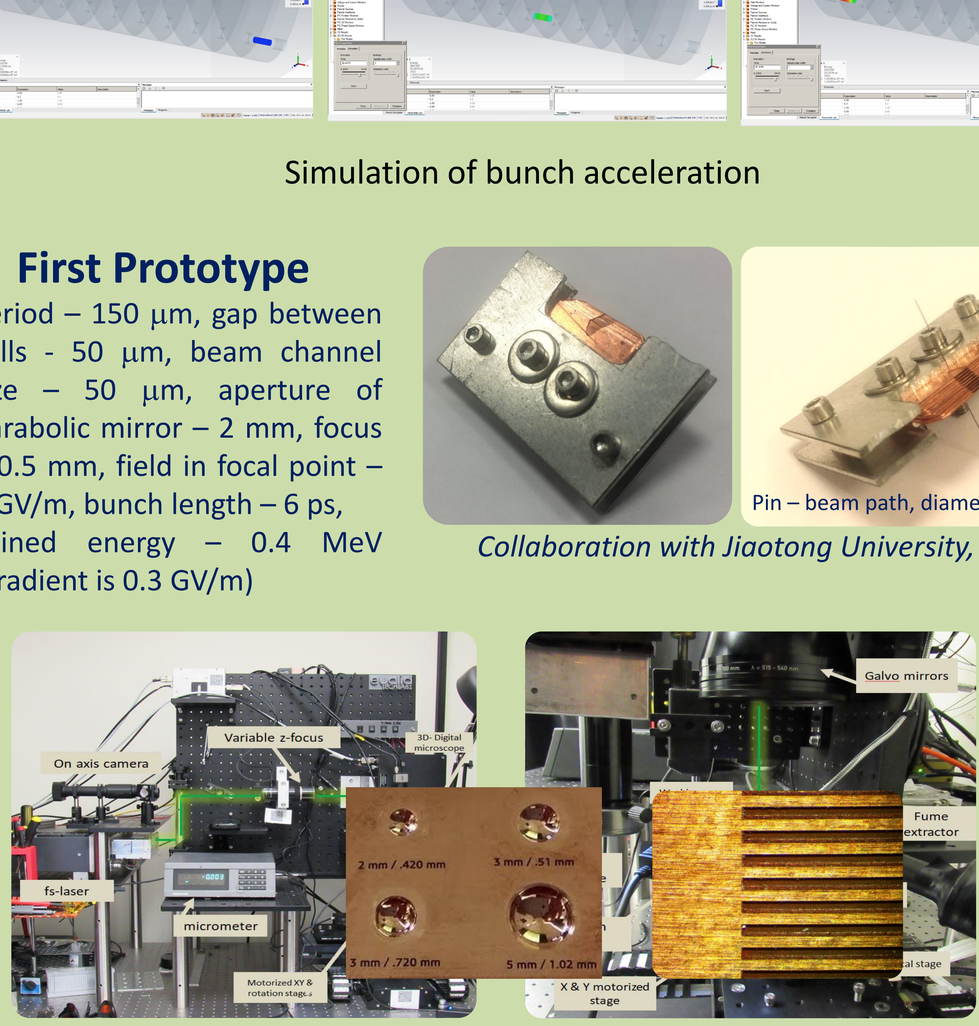
Simulation of bunch acceleration

First Prototype

Period – 150 μm, gap between cells - 50 μm, beam channel size – 50 μm, aperture of parabolic mirror – 2 mm, focus – 0.5 mm, field in focal point – 1 GV/m, bunch length – 6 ps, gained energy – 0.4 MeV (gradient is 0.3 GV/m)

Pin – beam path, diameter 200um

Collaboration with Jiaotong University, D. Xiang



Euclid Techlabs developed a femtosecond laser ablation process for diamond lens development.