Demonstration of Gigavolt-per-meter Accelerating Gradients using Cylindrical Dielectric-lined Waveguides

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1) Cook *et al*, Phys. Rev. Lett. 103 095003 (2009)

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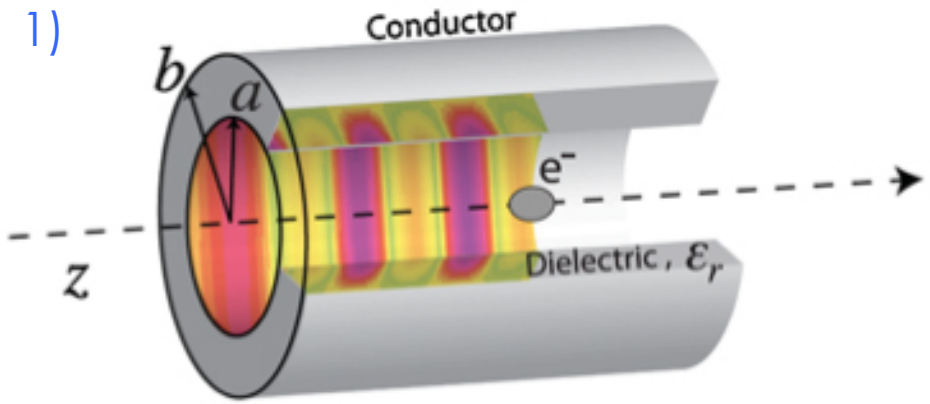
Dielectric Wakefield Accelerators

- Capable of GV/m gradients, 500 MV/m deceleration measured here
- Demonstrated sustained high breakdown threshold (~5 GV/m), structure lifetimes in excess of 10000 pulses obtained for this experiment
- Potential source of THz radiation
- Leverage nanofabrication procedures to produce structures

1)



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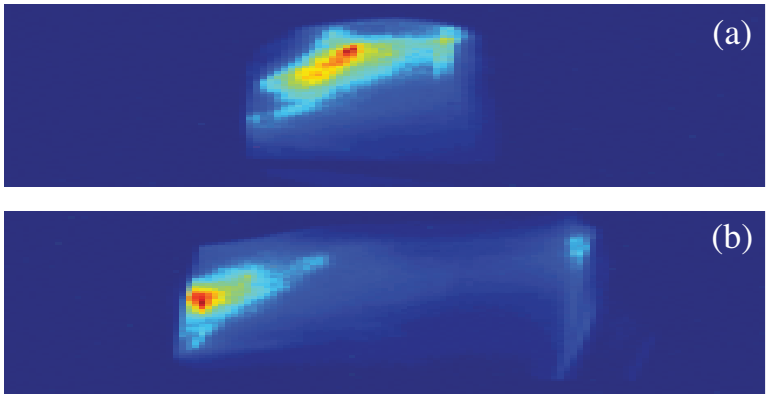
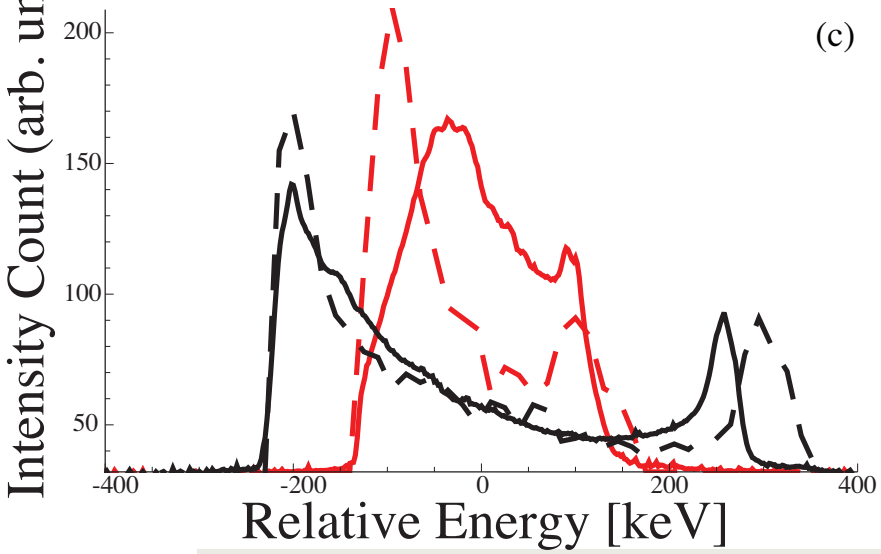
1) Andonian *et al*, Phy.s Rev. Lett. **108**, 244801 (2012)
2) Gai *et al*, Phys. Rev. Lett. **61**, 2756 (1988)
3) Antipov *et al*, Appl. Phys. Lett. **100**, 132910 (2012)

Dielectric Wakefield Accelerators

1)





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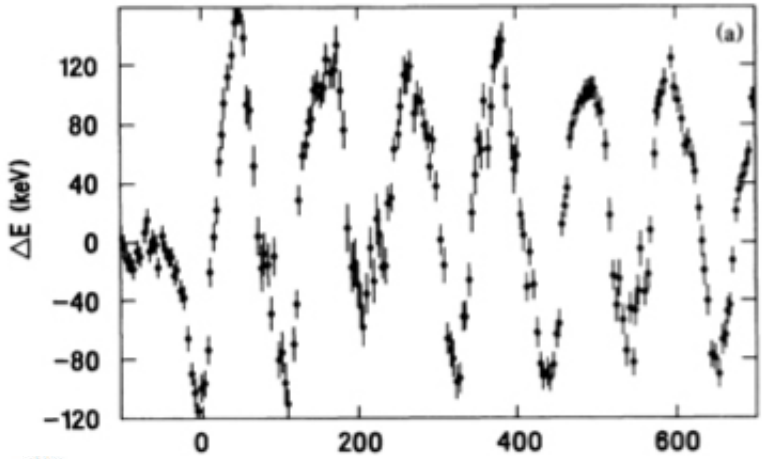

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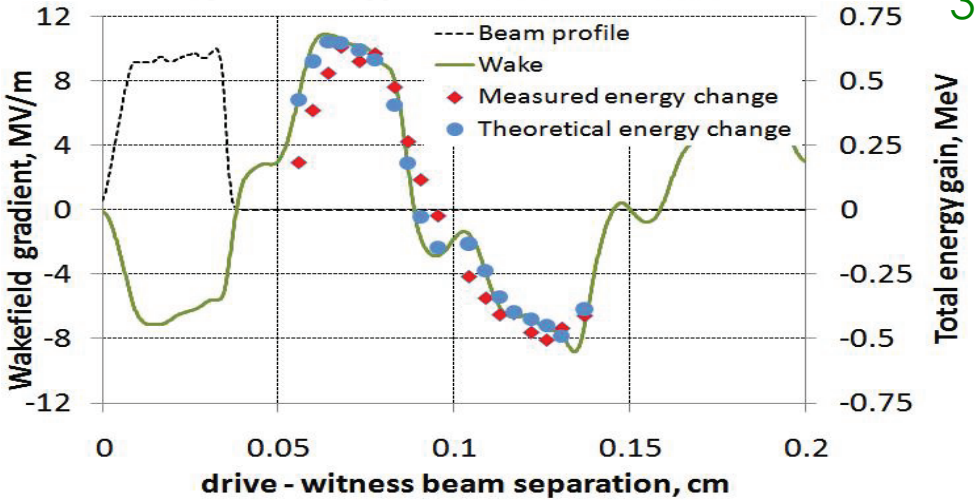

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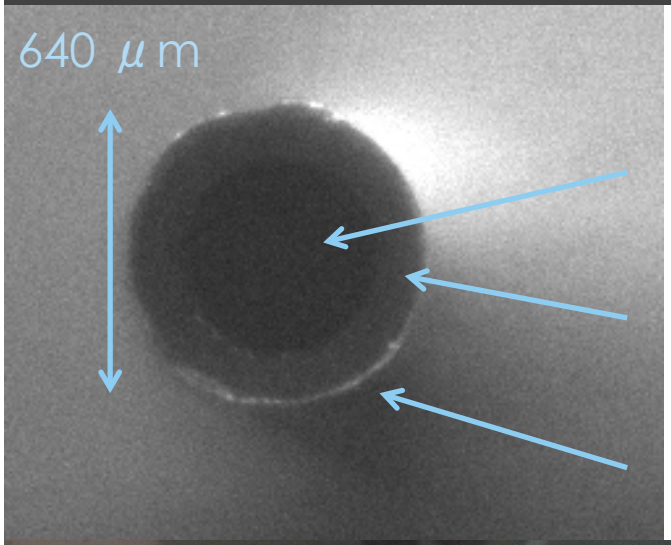
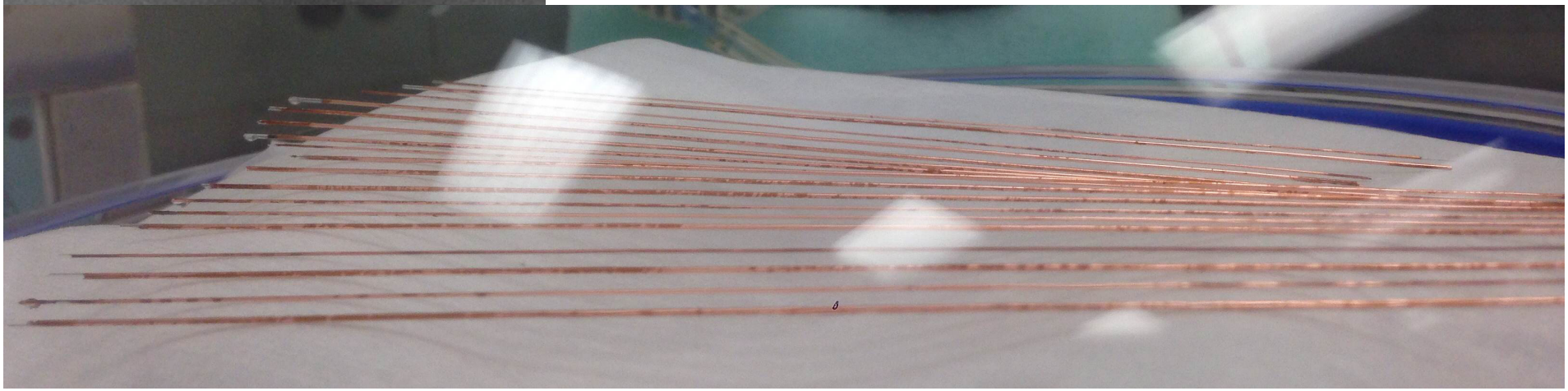
Structure Fabrication



- Vapor Deposition of Al (~30 nm) then Cu (~ 500 nm)
- Sulfate based copper electroplating bath adds Cu to at least 12.5 μm thickness
- Diamond saw cuts the tube to length



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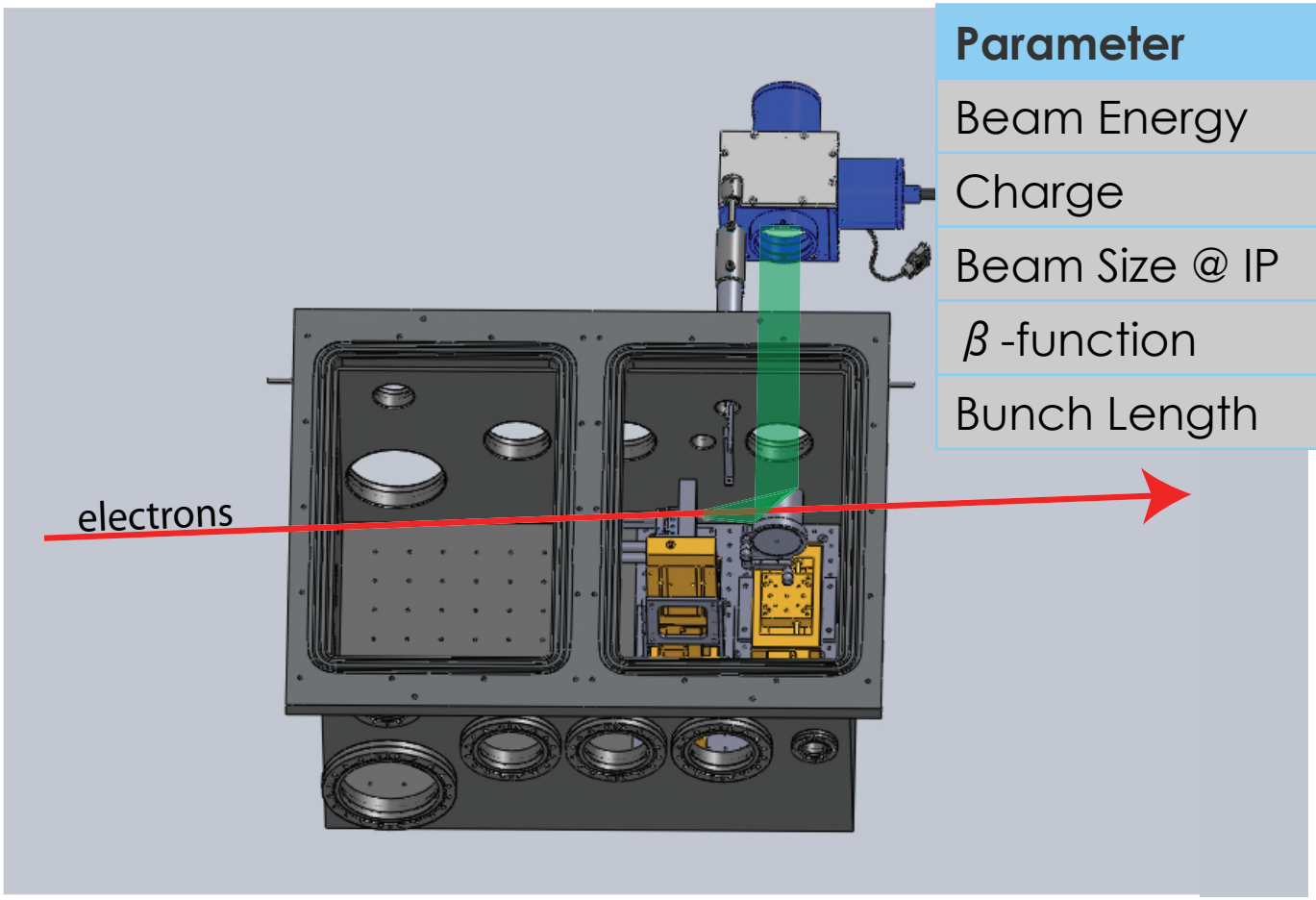

Parameter	Value
Beam Energy	20.35 GeV
Charge	3 nC
Beam Size @ IP	30x30 μ m
β -function	0.15x2.5 m
Bunch Length	20-100s μ m

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Coherent Cherenkov Radiation

Removed pending publication

- Narrowband THz
  - 400 GHz (750 μm)
  - 1.2 THz (250 μm)
- Unprecedented THz energies theoretically possible.
  - >100 mJ
  - Not yet completely characterized

a) 1 cm tube Autocorrelation Trace
b) Spectrum of a)
c) 10 cm 450/640 tube spectrum
d) 10 cm 400 um steel tube spectrum

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Energy Loss

500 MV/m

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- Average energy loss of 50 MeV (~150 mJ), 500 MV/m gradient
- Spectrometer set to image, no deflection information
- 1700 measurements with beam through structure, 600 no structure

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1) Nieter *et al*, J. Comp. Phys. 196 (2004) 448-473

Simulations

- Mathematica used to quickly solve analytically
- VORPAL for fully 3D PIC[1]

1. Measured bunch shape
2. VORPAL
3. Mathematica

Removed pending publication

Latest Results and Future Work

400 μm ID, 600 μm OD 15 cm

800 MV/m

Removed pending publication

Average energy loss of 120 MeV (~360 mJ)

300 μm ID, 400 μm OD 15 cm

2 GV/m

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Average energy loss of 300 MeV (~900 mJ)