

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

Brendan O'Shea, Oliver Williams, Gerard Andonian, Jere Harrison,
Kristin Fitzmorris, Sam Barber, James Rosenzweig, **Mark Hogan**,
Vitaly Yakimenko

LINAC 2014

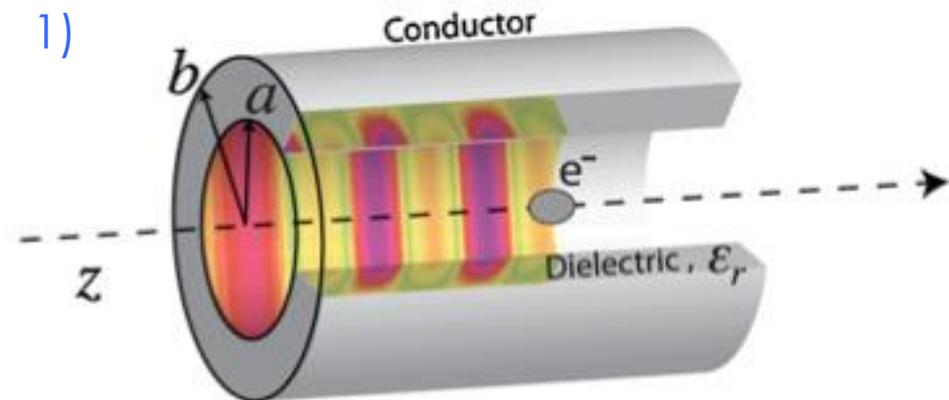
Geneva

UCLA

SLAC

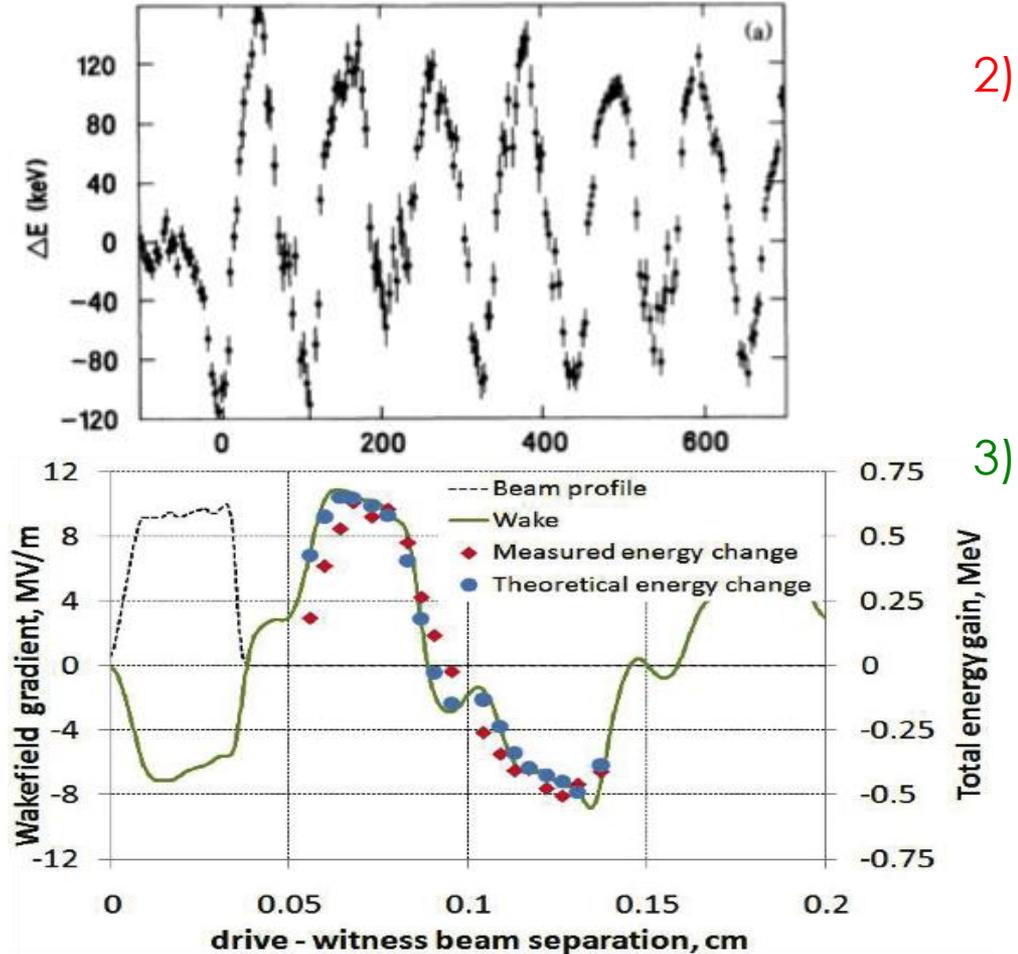
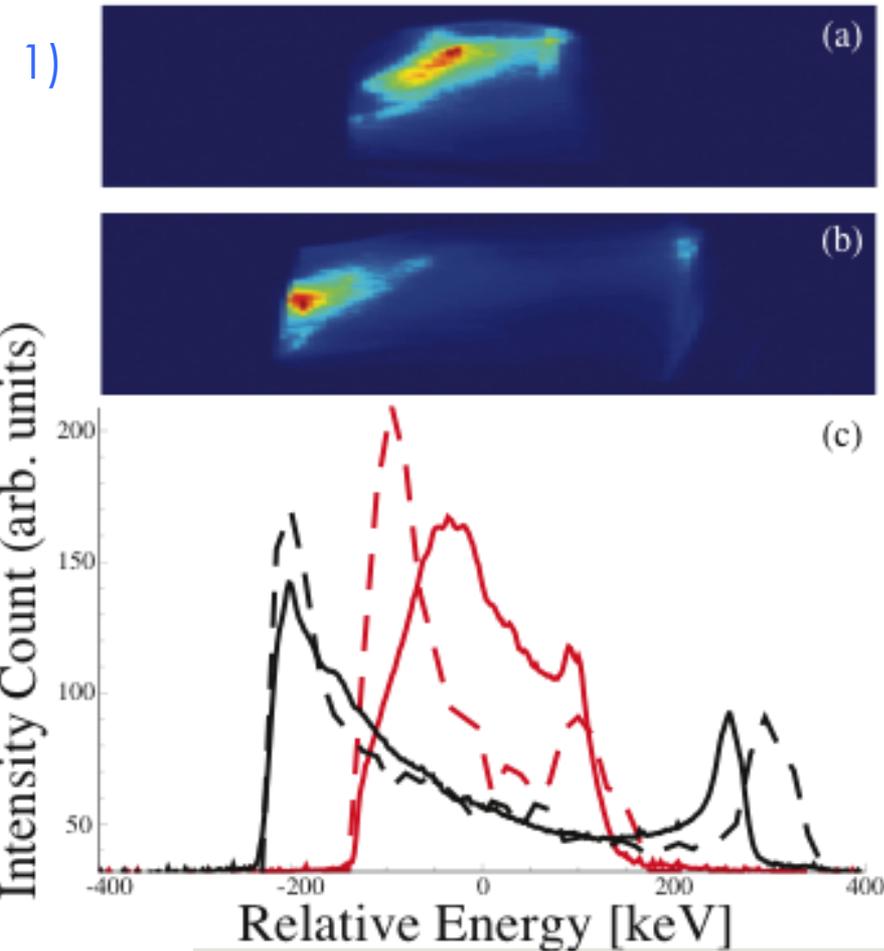
Dielectric Wakefield Accelerators

- Capable of GV/m gradients, 0.5-2 GV/m deceleration measured here
- Demonstrated sustained high breakdown threshold (~ 5 GV/m), structure lifetimes in excess of 10000s pulses obtained for this experiment
- Potential source of THz radiation
- Leverage nanofabrication procedures to produce structures
- 10 MV/m demonstrated previously

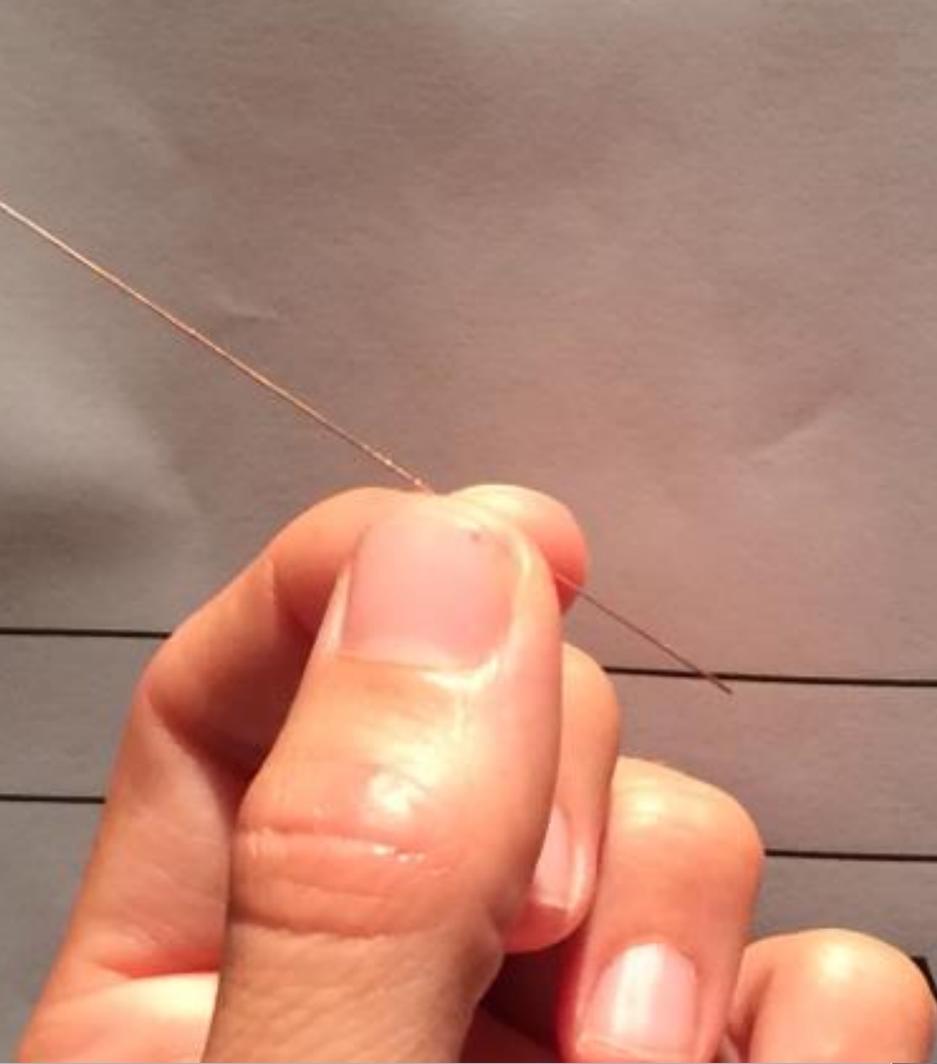


- 1) Andonian *et al*, Phys. Rev. Lett. **108**, 244801 (2012)
- 2) Gai *et al*, Phys. Rev. Lett. **61**, 2756 (1988)
- 3) Antipov *et al*, Appl. Phys. Lett. **100**, 132910 (2012)

Dielectric Wakefield Accelerators

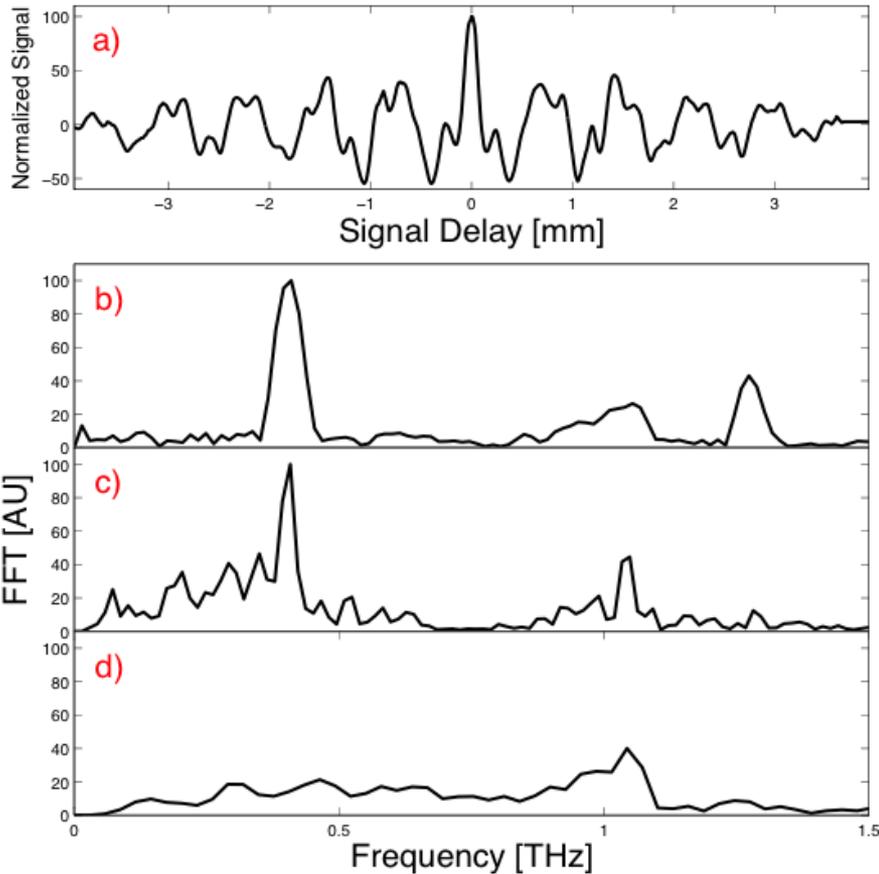


energy science applications.



Accelerators

Coherent Cherenkov Radiation



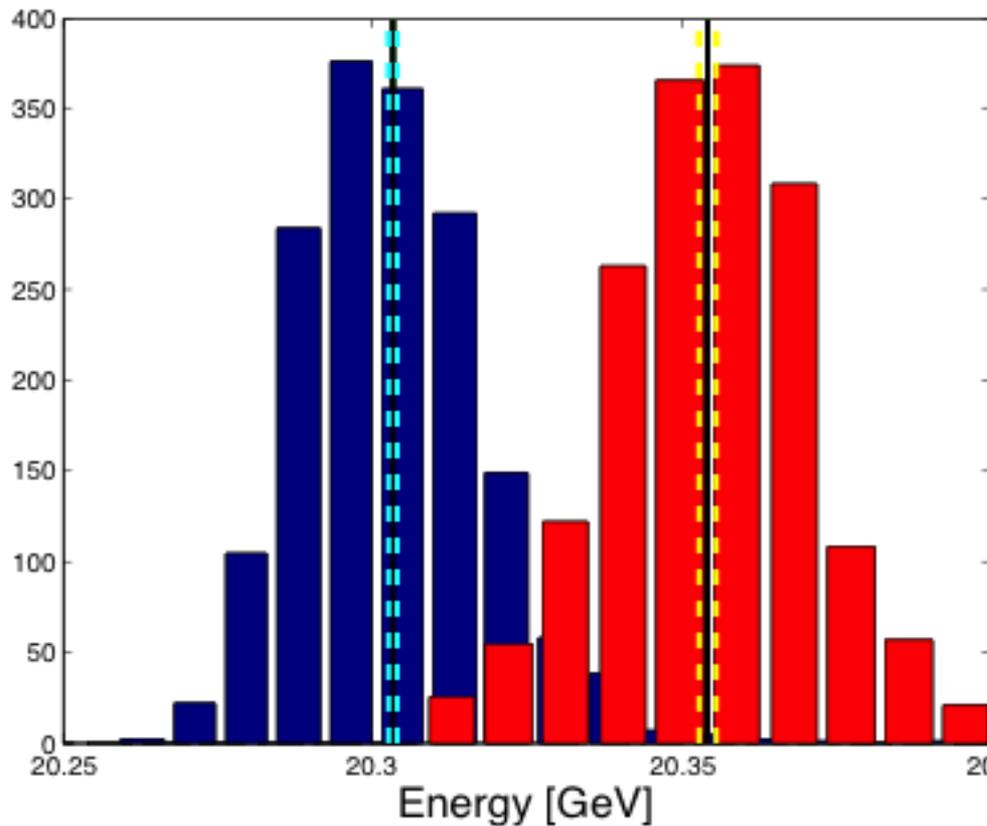
- Narrowband THz
 - 400 GHz (750 μm)
 - 1.2 THz (250 μm)

- Unprecedented THz energies theoretically possible.
 - >100 mJ
 - Not yet completely characterized

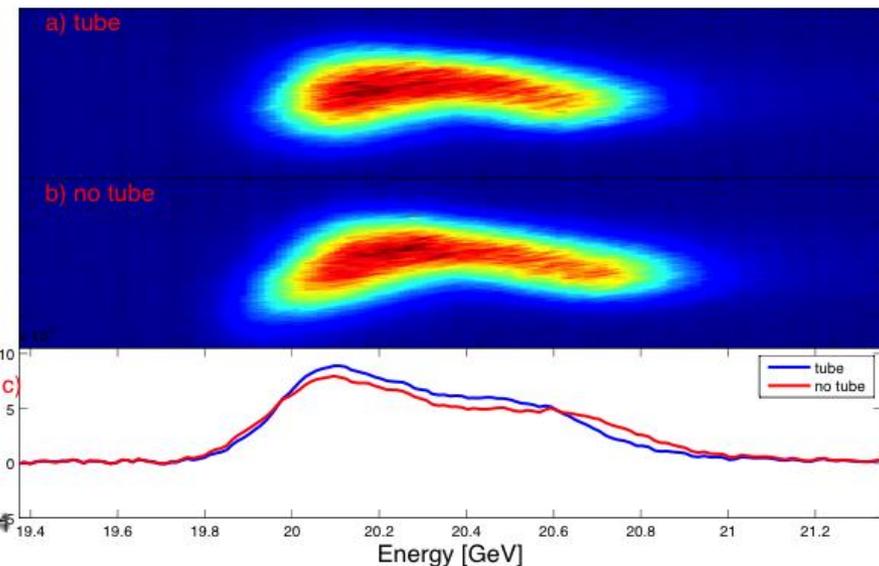
- a) 1 cm tube Autocorrelation Trace
- b) Spectrum of a)
- c) 10 cm 450/640 tube spectrum
- d) 10 cm 400 um steel tube spectrum

Energy Loss

500 MV/m



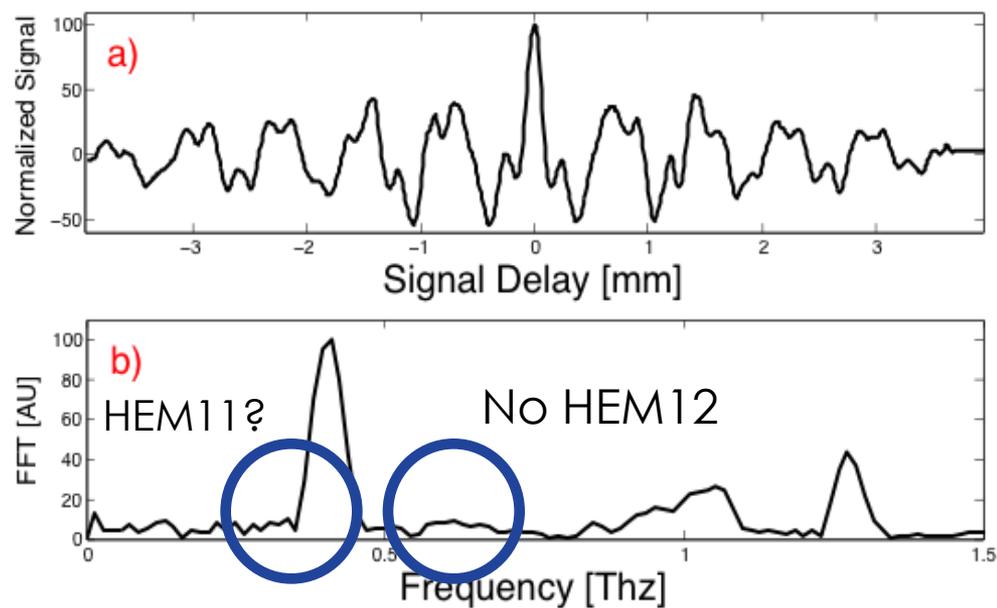
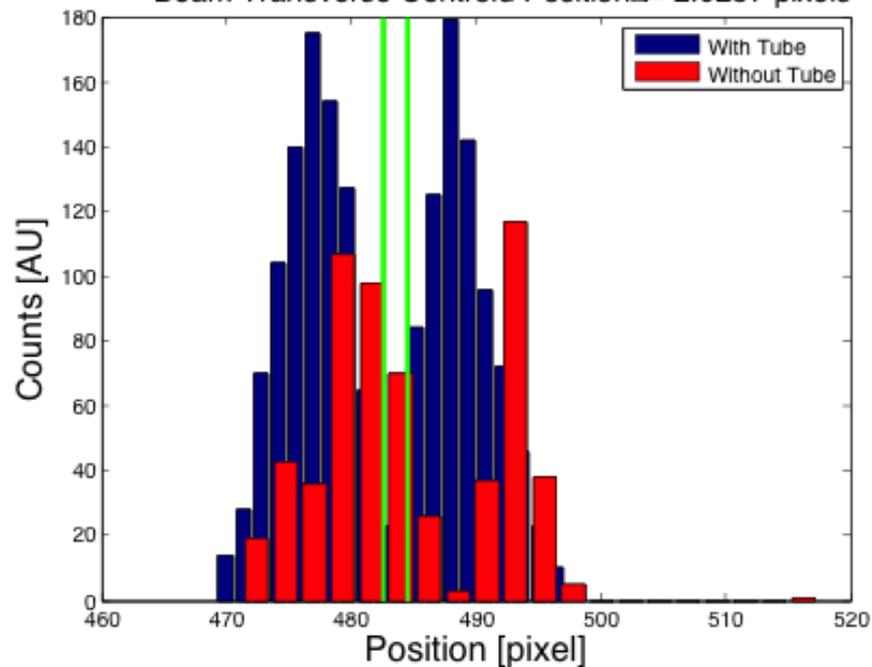
- Average energy loss of 50 MeV (~150 mJ), 500 MV/m gradient
- Spectrometer set to image, no deflection information
- 1700 measurements with beam through structure, 600 no structure



HEM Modes?

Offset $\sim 80\mu\text{m}$

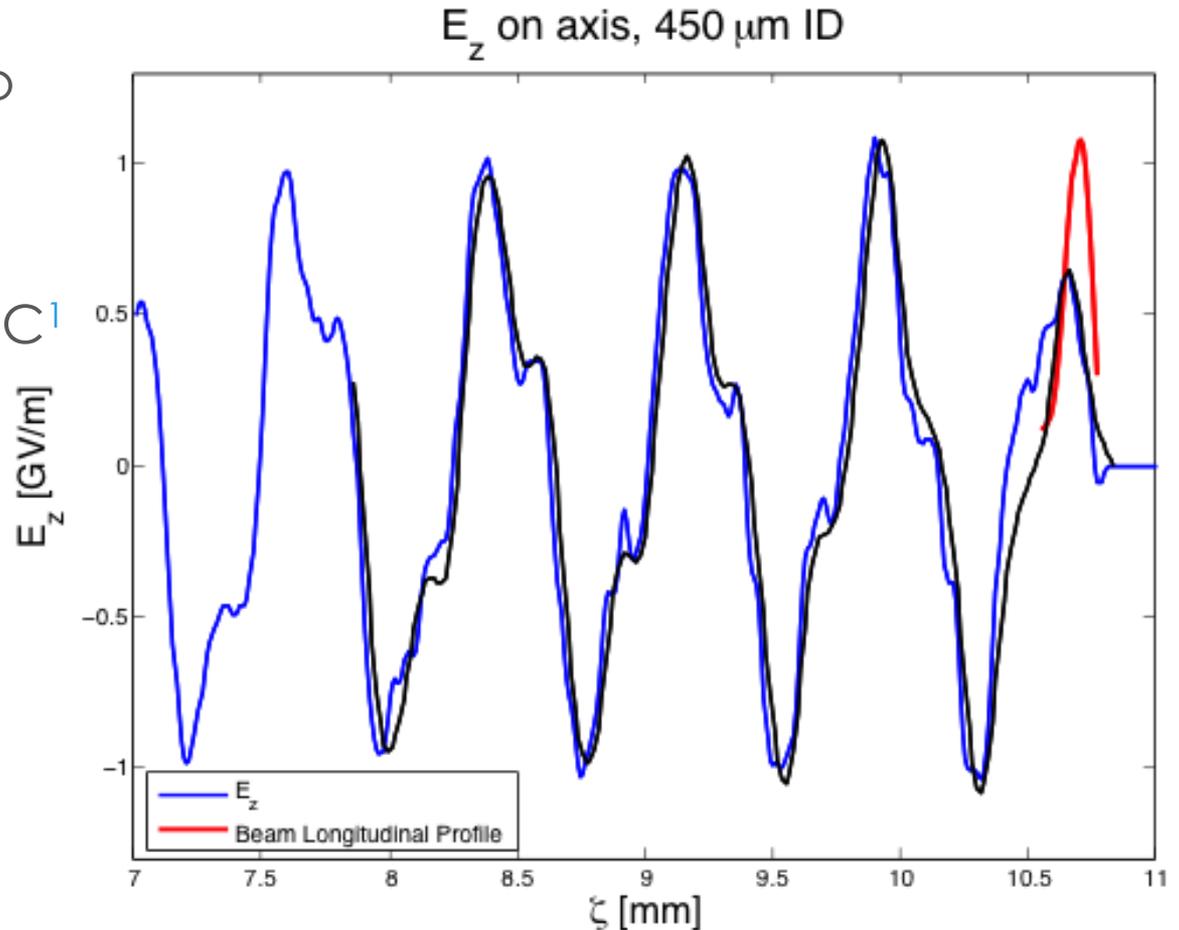
Beam Transverse Centroid Position $\Delta = 2.0257$ pixels



Simulations

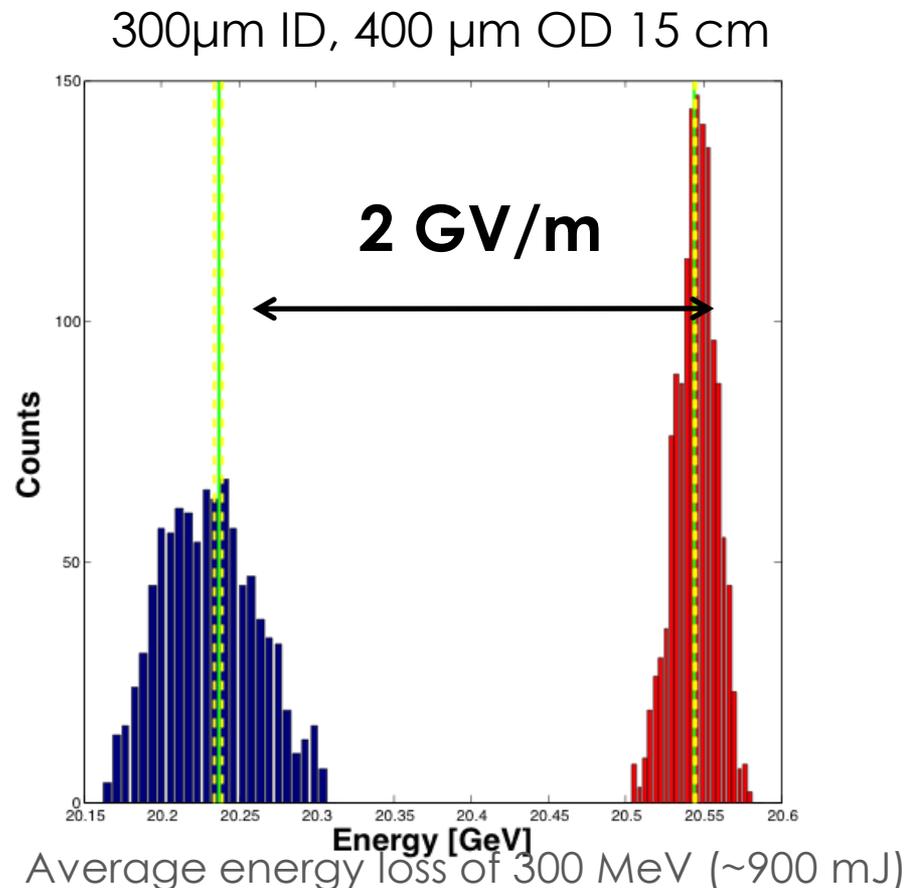
- Mathematica used to quickly solve analytically
- VORPAL for fully 3D PIC¹

- Measured bunch shape
- VORPAL
- Mathematica



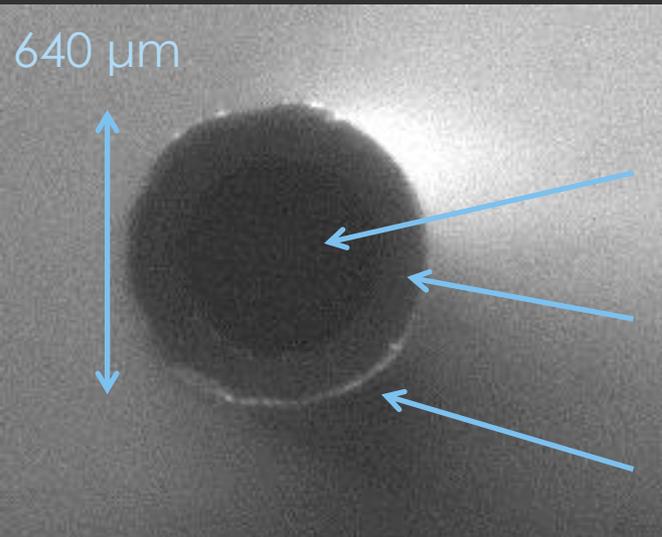
Latest Results and Future Work

- Demonstrated sustained \sim GV/m gradients
- Characterized beam-structure interaction
- Witness bunch acceleration!
- Examine beam break-up in structures with smaller transverse dimensions

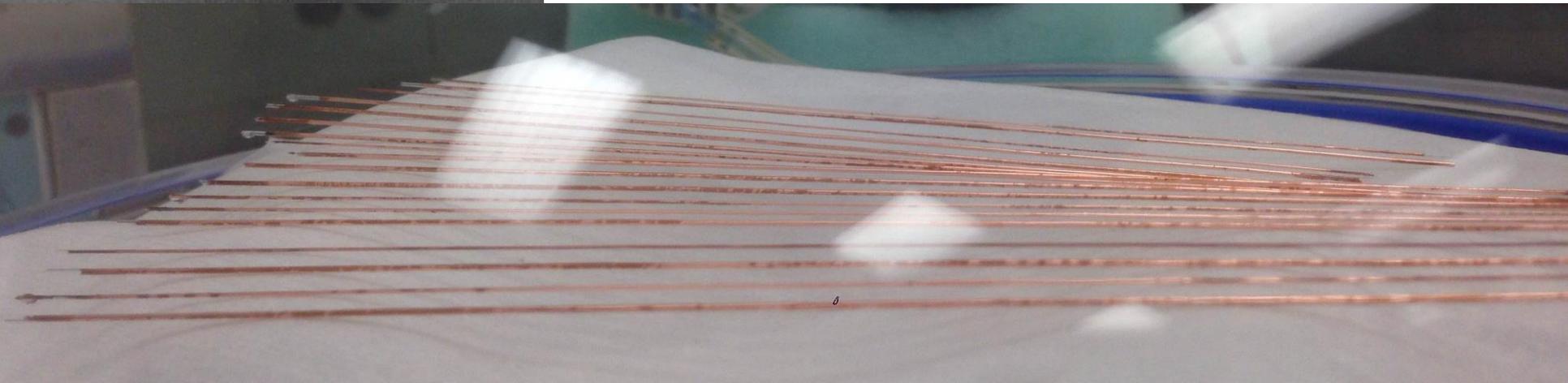


Extra Material

Structure Fabrication

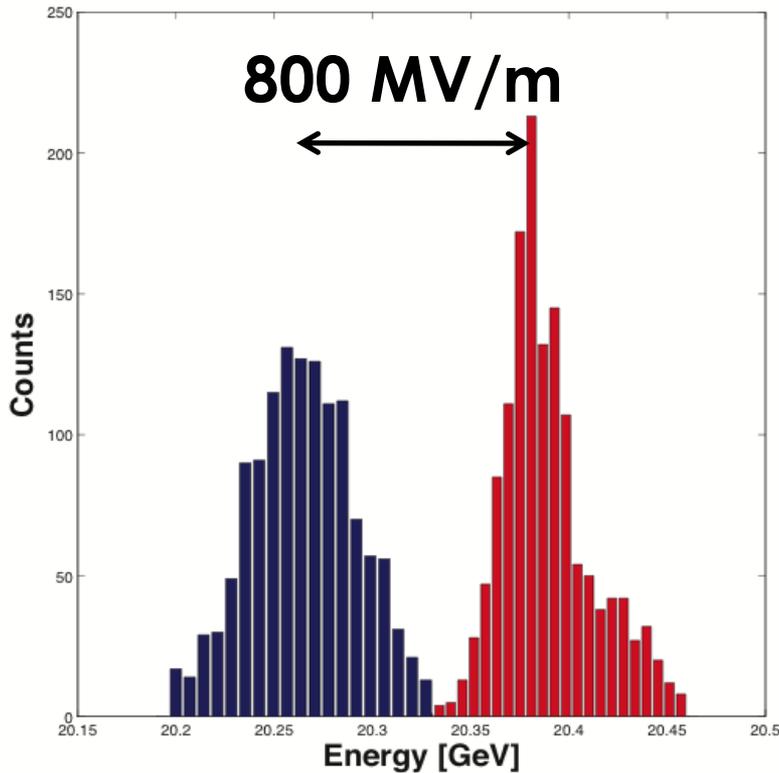


- Vapor Deposition of Al (~30 nm) then Cu (~500 nm)
- Sulfate based copper electroplating bath adds Cu to at least 12.5 μm thickness
- Diamond saw cuts the tube to length



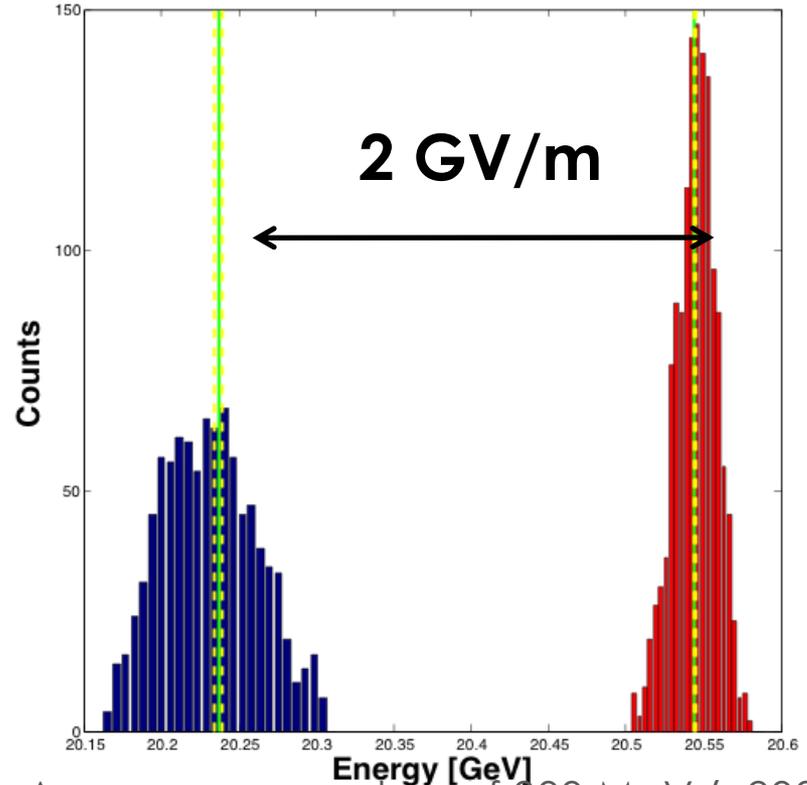
Latest Results and Future Work

400 μ m ID, 600 μ m OD 15 cm



Average energy loss of 120 MeV (~360 mJ)

300 μ m ID, 400 μ m OD 15 cm



Average energy loss of 300 MeV (~900 mJ)

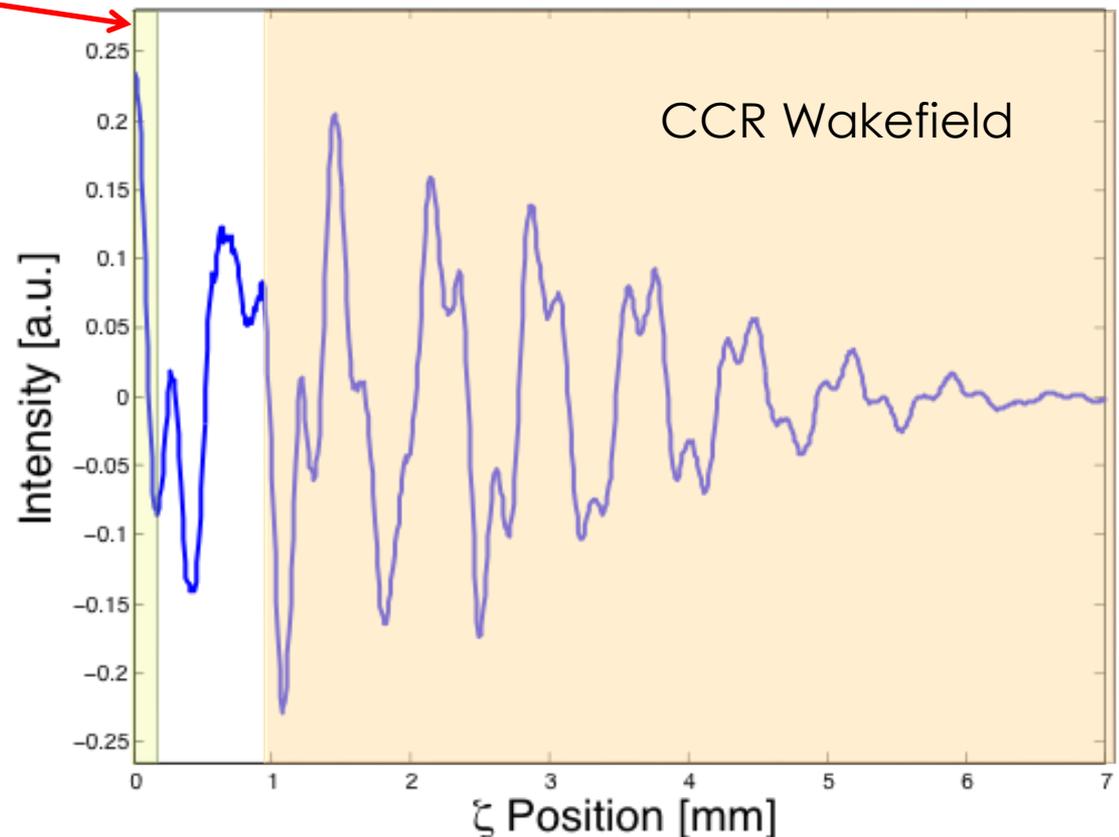
KK Reconstruction of Wakefield

- ▣ Allows extraction of beam and CCR pulse parameters
- ▣ Spectral content of wakefield evident
- ▣ Specific wakefield properties under study
- ▣ Fluence $\sim 30 \text{ J/cm}^2$ for 100 ps long pulse

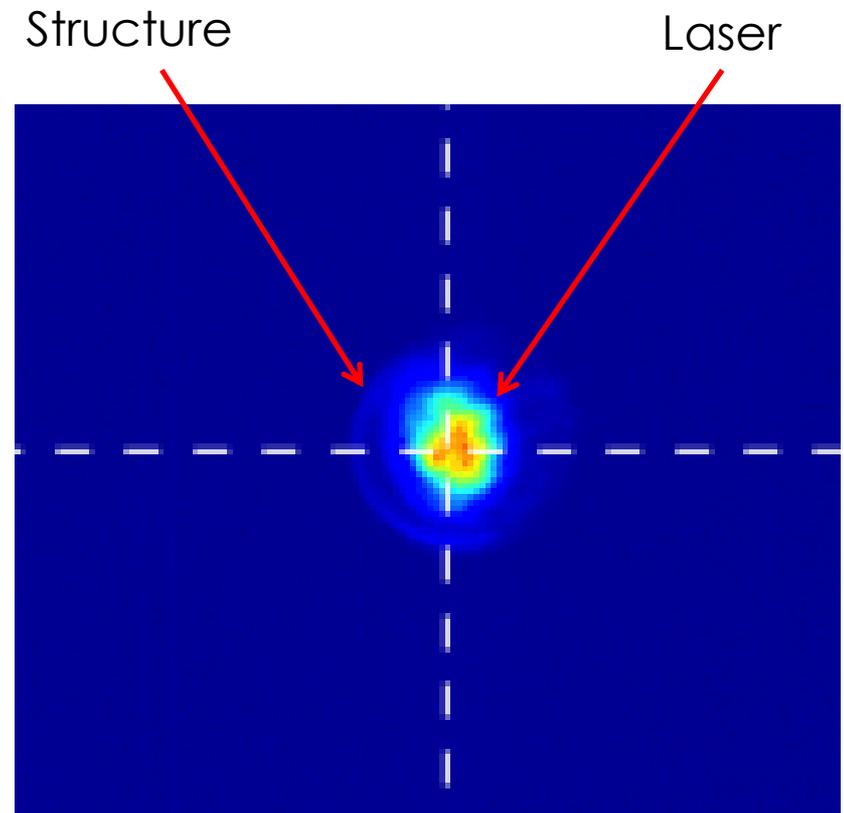
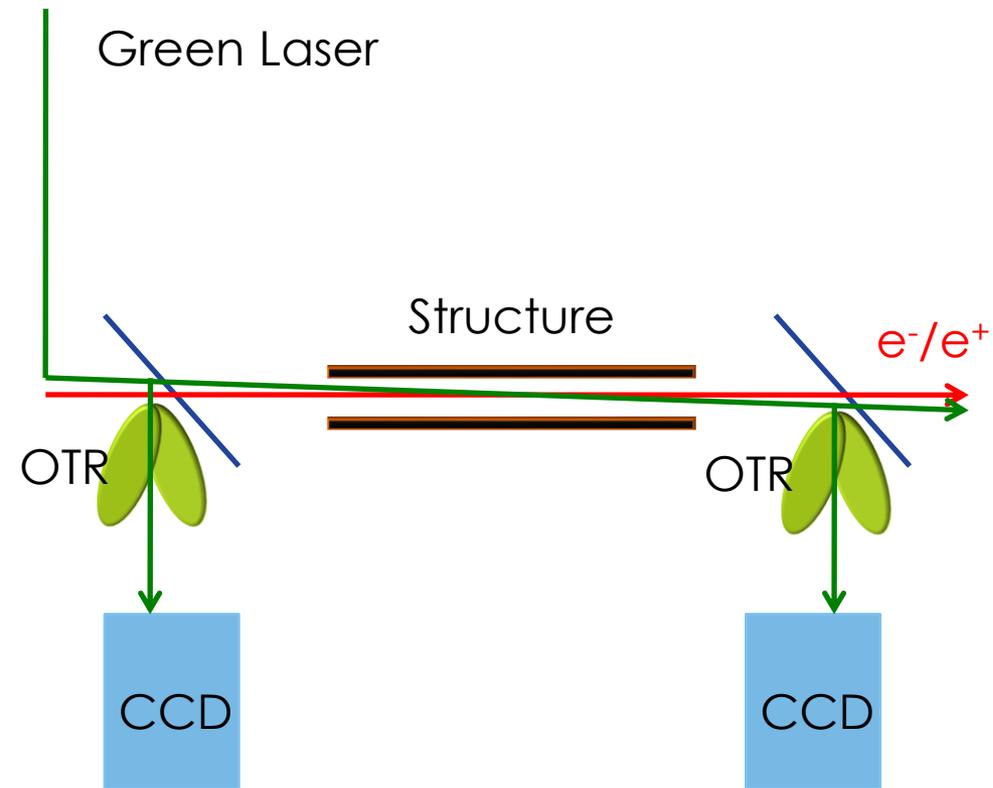
Beam



KK Reconstruction of the 1 CM Data



Alignment



FACET Beamline

