

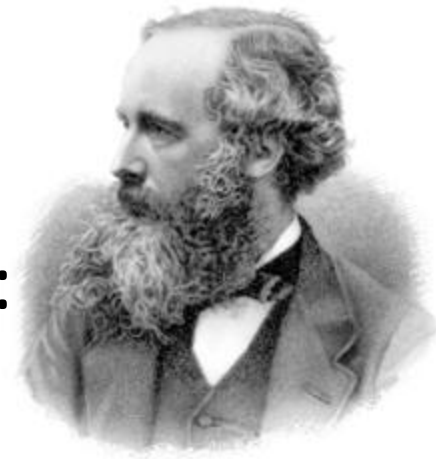


# Dielectric Wakefield Acceleration

François Lemery

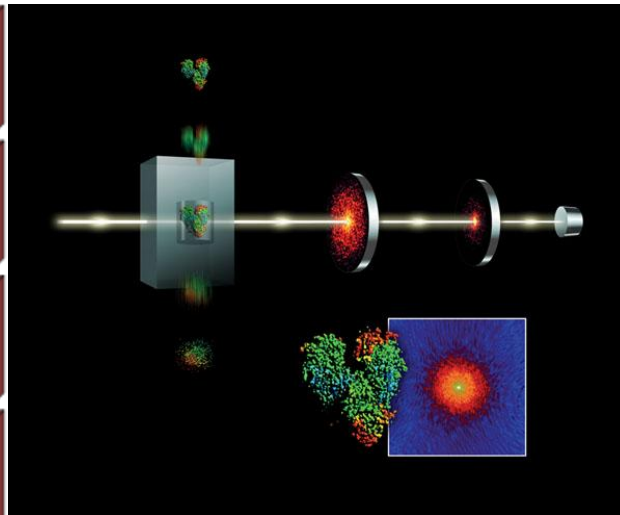
# Motivation

- Accelerators have led to new science:
  - HEP
  - Light sources (Chemistry, Biology, Materials)
  - Cost
  - Maximum RF gradients  $\sim 100\text{MV/m}$ .



Three Generations of Matter (Fermions)

	I	II	III	
mass	2.4 MeV/c <sup>2</sup>	1.27 GeV/c <sup>2</sup>	171.2 GeV/c <sup>2</sup>	0
charge	$\frac{2}{3}$	$\frac{2}{3}$	$\frac{2}{3}$	0
spin	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	1
name	u	c	t	$\gamma$
	up	charm	top	photon
	4.8 MeV/c <sup>2</sup>	104 MeV/c <sup>2</sup>	4.2 GeV/c <sup>2</sup>	0
	$-\frac{1}{3}$	$-\frac{1}{3}$	$-\frac{1}{3}$	0
	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	1
	d	s	b	g
	down	strange	bottom	gluon
	< 2.2 eV/c <sup>2</sup>	< 0.17 MeV/c <sup>2</sup>	< 15.5 MeV/c <sup>2</sup>	91.2 GeV/c <sup>2</sup>
	0	0	0	0
	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	1
	$\nu_e$	$\nu_\mu$	$\nu_\tau$	$Z^0$
	electron neutrino	muon neutrino	tau neutrino	Z boson
	0.511 MeV/c <sup>2</sup>	105.7 MeV/c <sup>2</sup>	1.777 GeV/c <sup>2</sup>	80.4 GeV/c <sup>2</sup>
	-1	-1	-1	$\pm 1$
	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	1
	e	$\mu$	$\tau$	$W^\pm$
	electron	muon	tau	W boson



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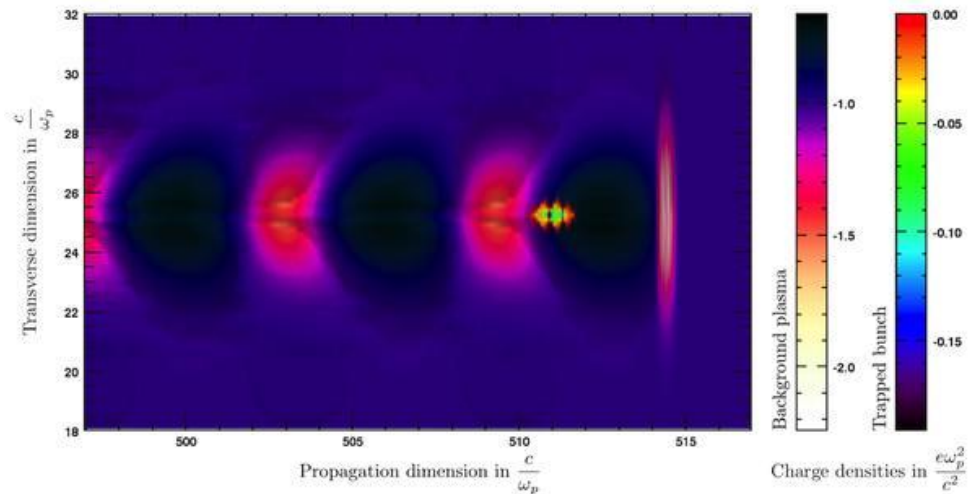
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# Types of Wakefield Accelerators

- Laser driven plasma wakefield acceleration
- Beam driven plasma wakefield acceleration
- Dielectric Loaded Waveguides (DLW)



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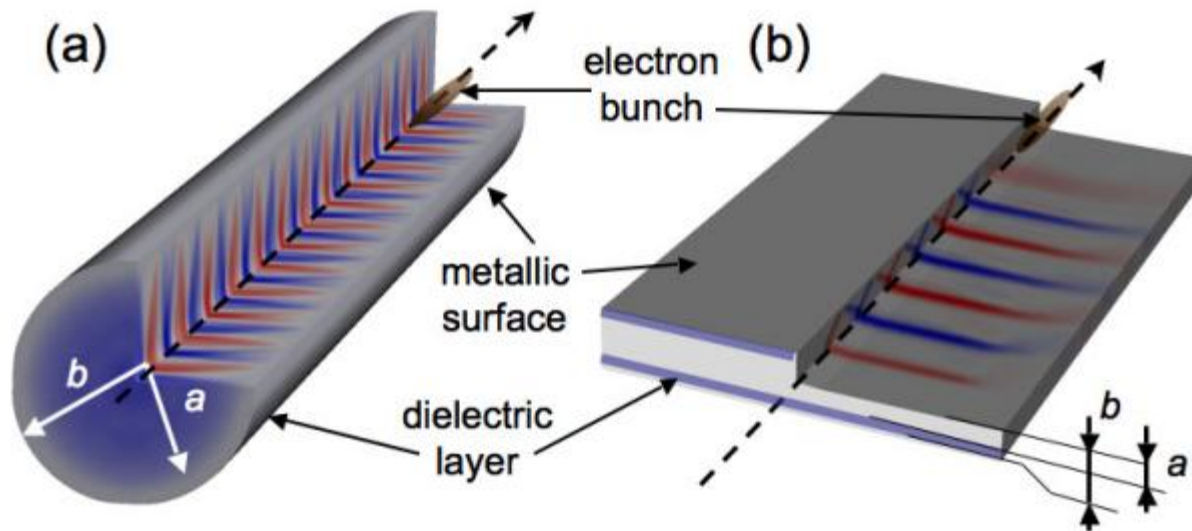


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# Dielectric Loaded Waveguides

Cylindrical, Slab...

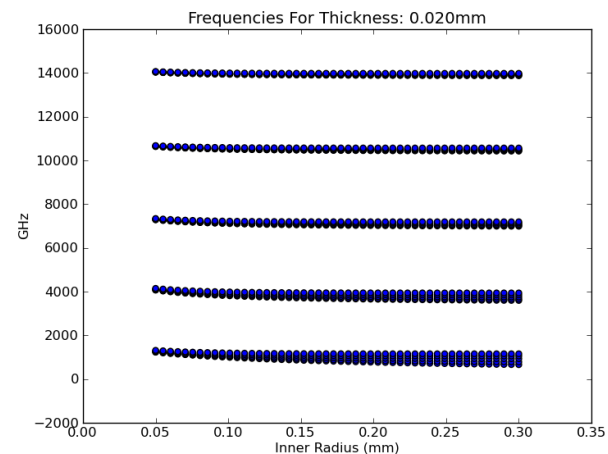
$$\delta = b - a$$



\*Dielectric restricts phase velocities  $< c$ !

# Understanding

- Resonant frequencies(monopole, dipoles ..)
  - Dispersion equation
- Mode coupling
  - Understood by looking at the frequency space of current profile.

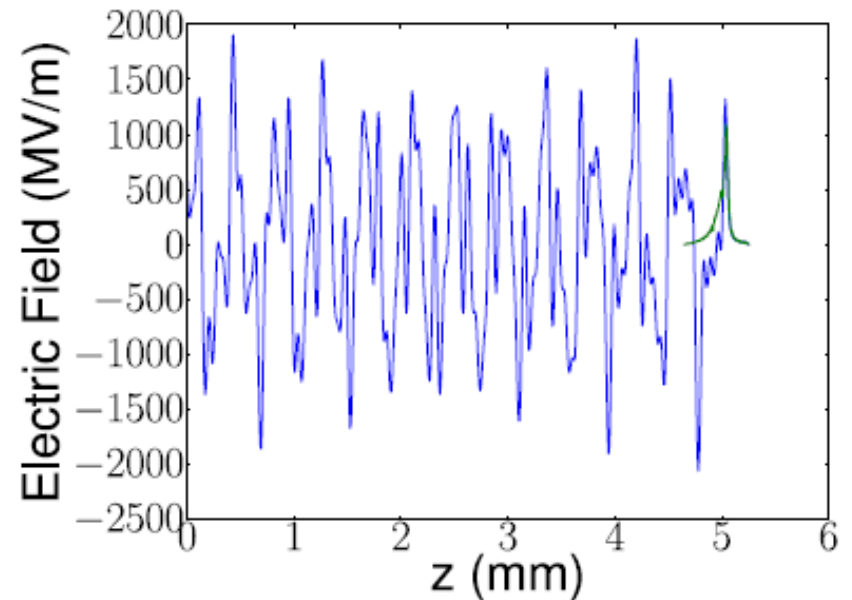
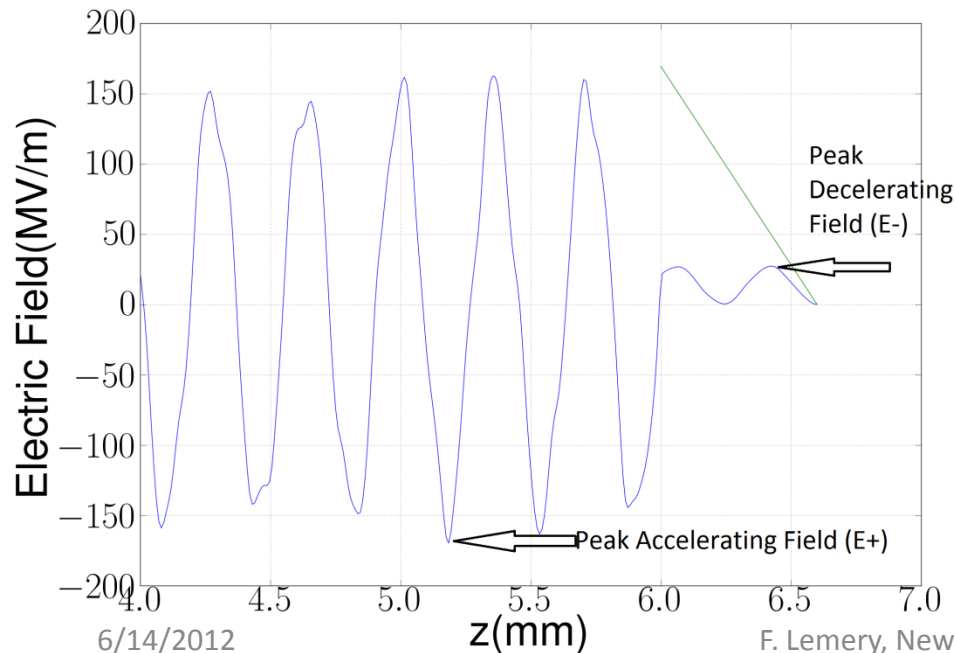


Slab  
geometry



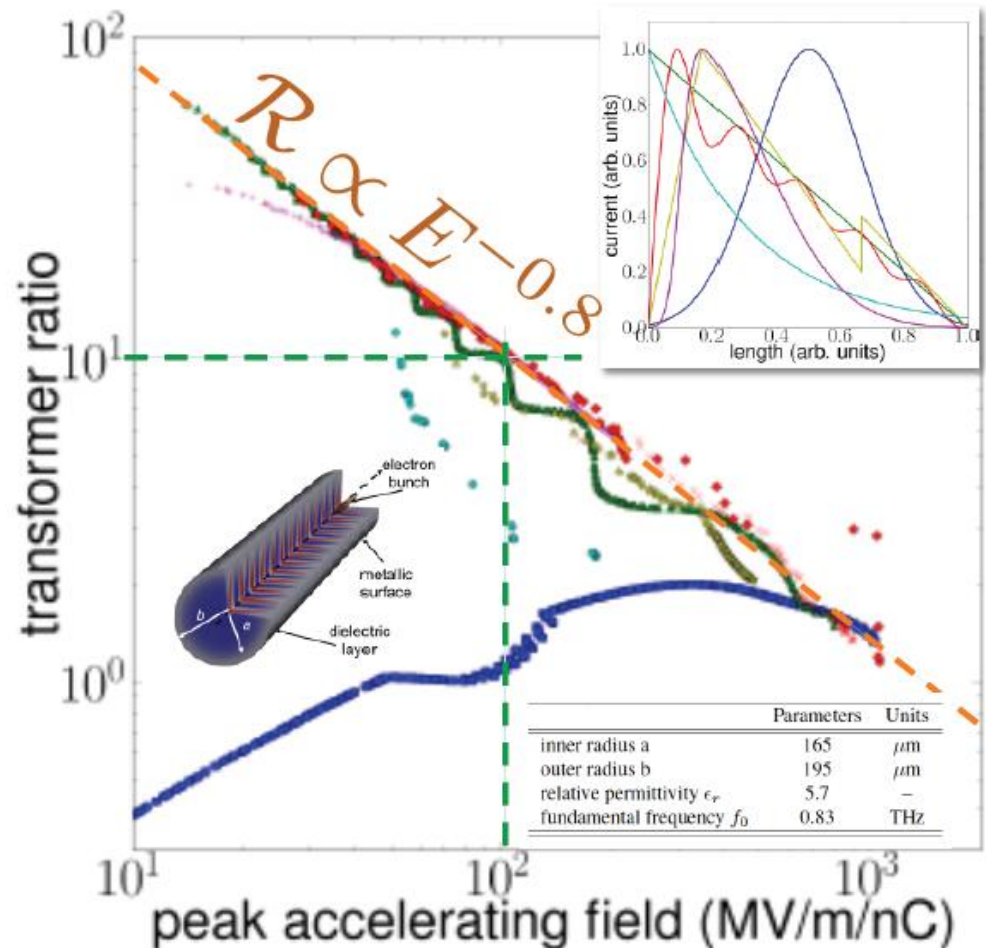
# Understanding the Wake

- Transformer Ratio ( $R = \text{Abs}(E_+/E_-)$ )
  - Fundamental Wakefield Theorem (Sym. Bunch:  $R < 2$ )
- Energy modulation (bad).
- Witness bunch must fit in bucket!



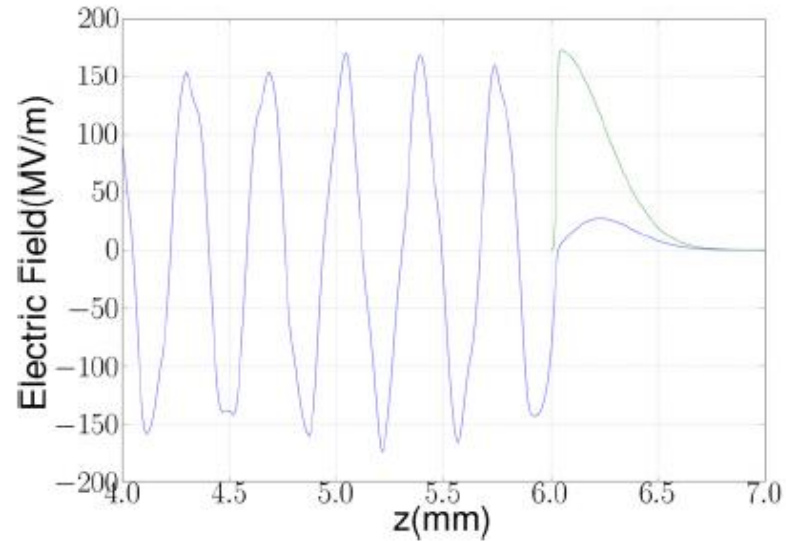
# Pulse Shaping

- Very important!
- Maximize both  $E$  and  $R$ .
- Reduce energy spread.

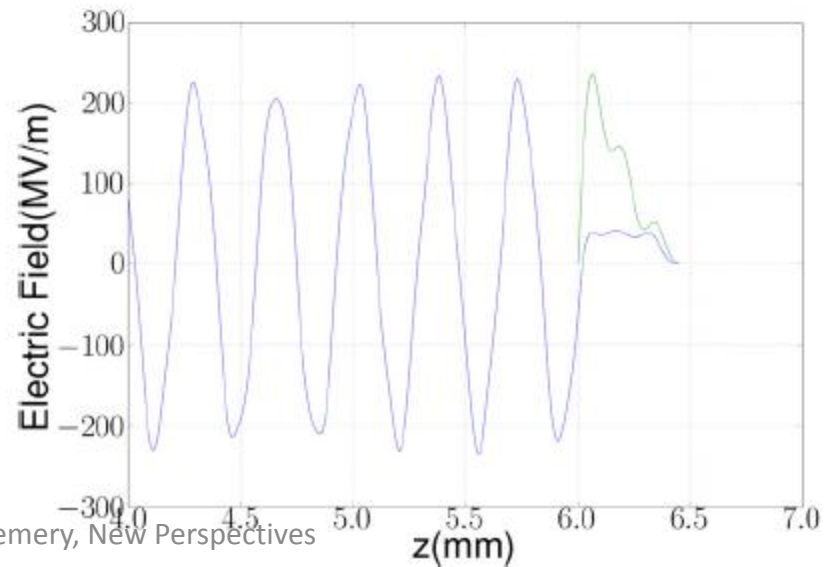


# Pulse Shaping Continued

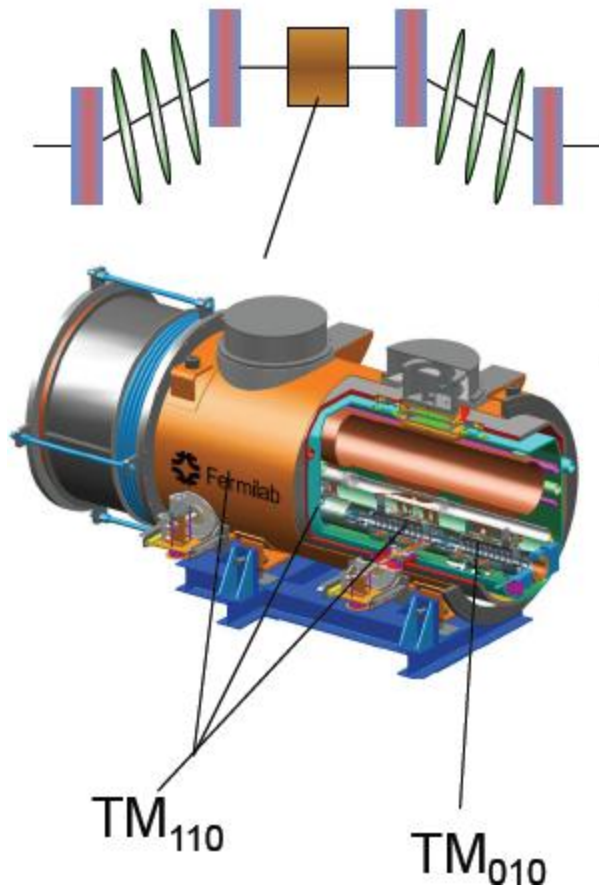
- Skewed Gaussian



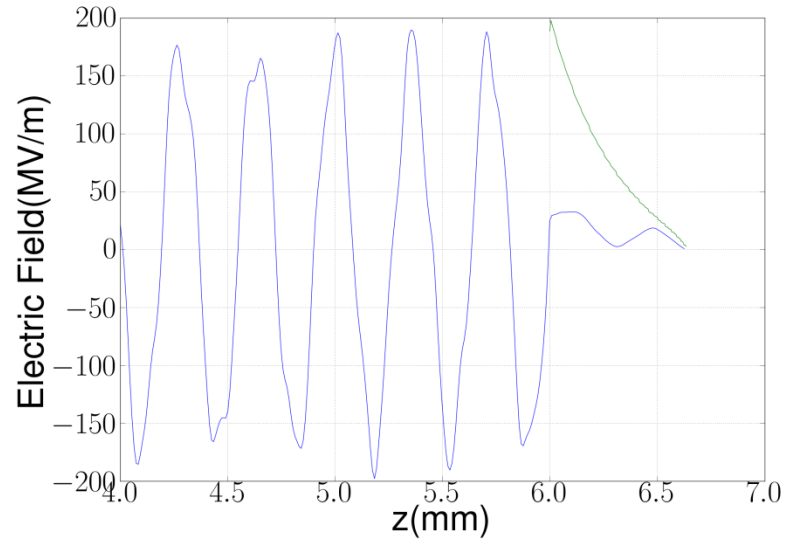
- Fourier Ramp



# Pulse Shaping Continued



Emittance Exchanger (EEX) for very flexible shaping

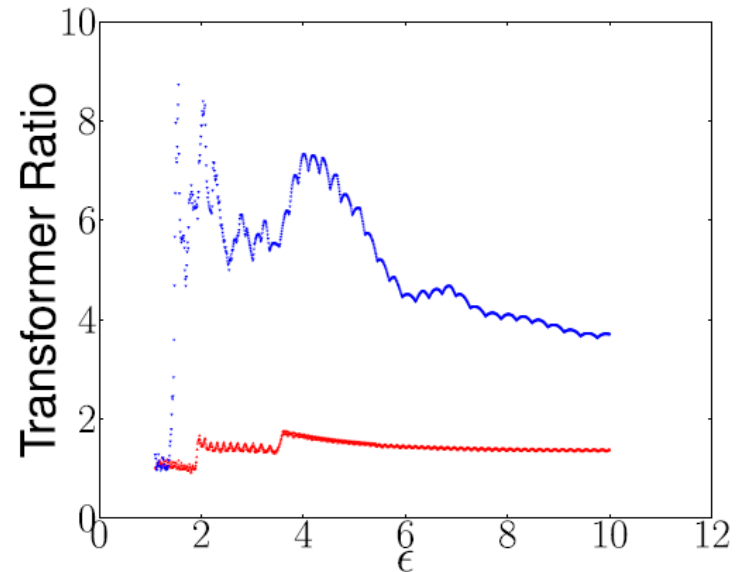
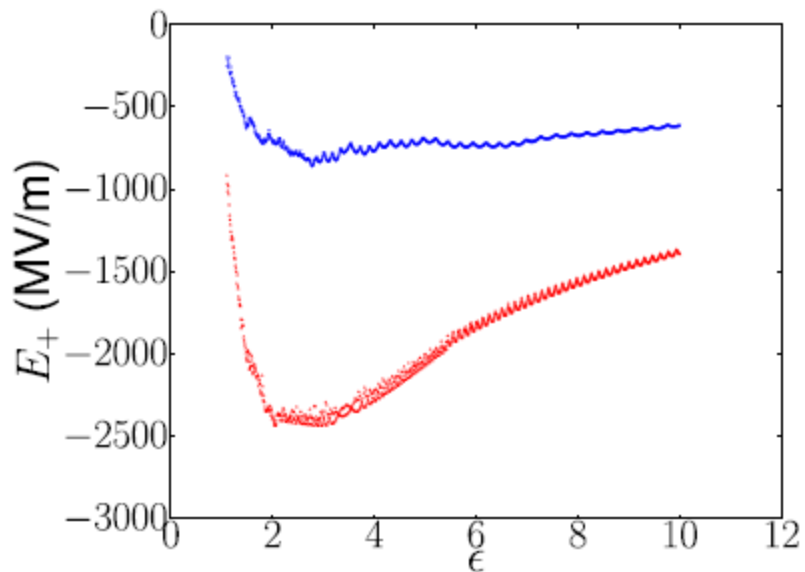


Achievable using multi frequency RF booster

\*Both will be available at ASTA!

# Dielectric Considerations

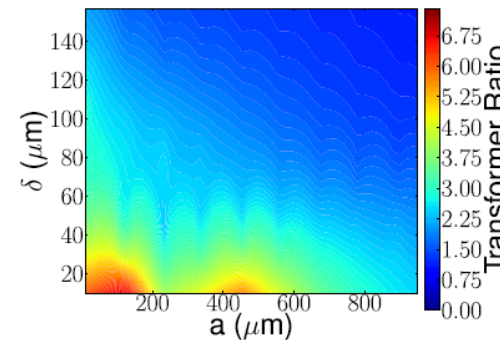
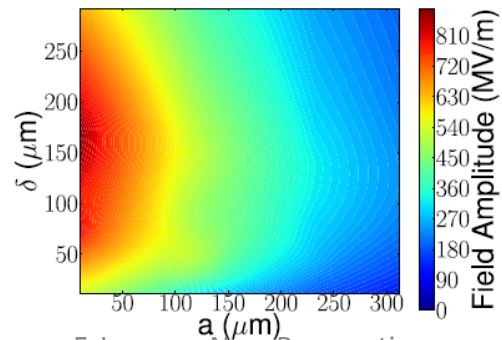
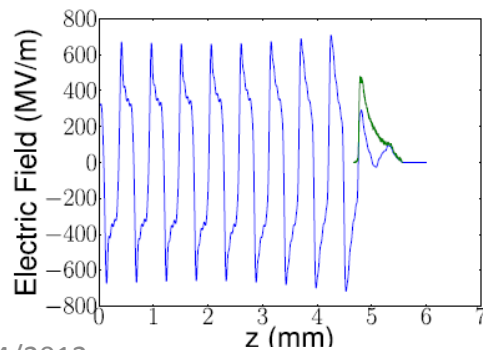
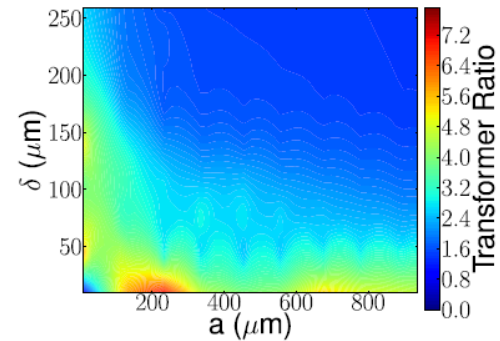
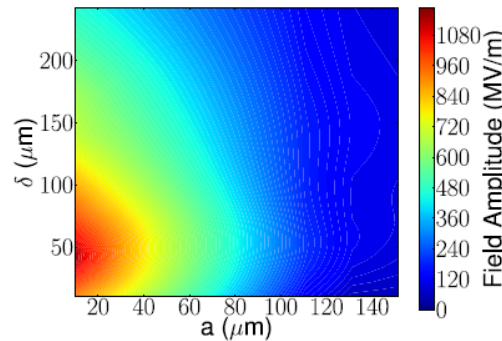
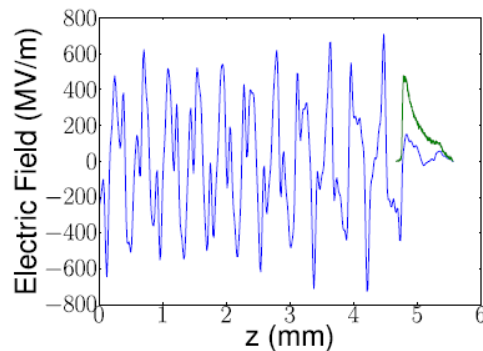
- $E_+$  and R highly dependent on electric permittivity of dielectric.



Short Gaussian bunch(red), Linearly ramped bunch (blue)

# Round vs Flat Beam

- Round beams have more stringent requirement on betatron functions

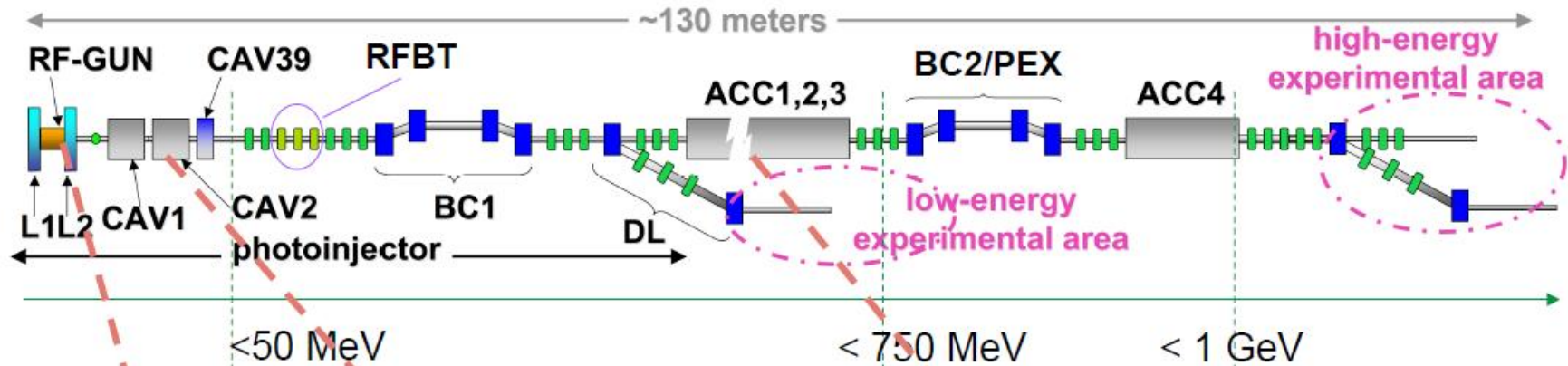


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$$(a, \delta) = (20, 60) \mu\text{m}.$$

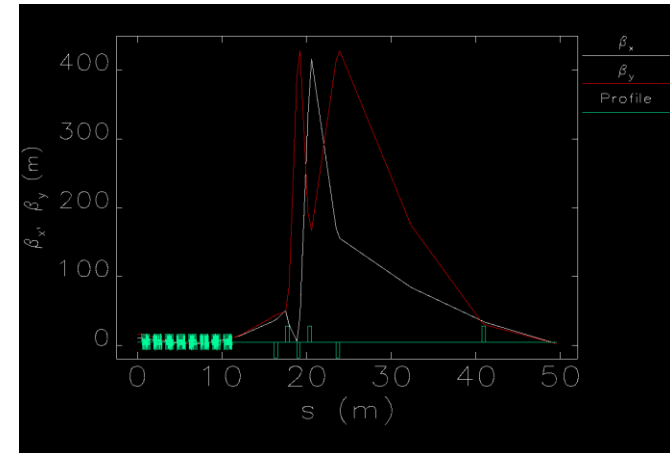
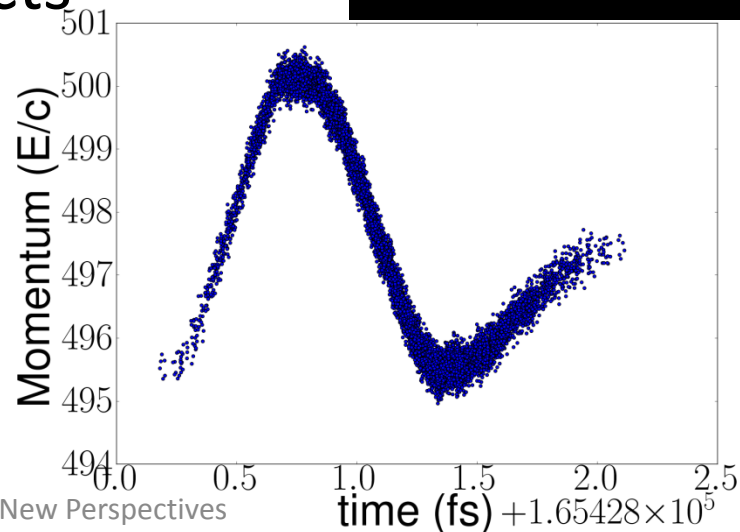
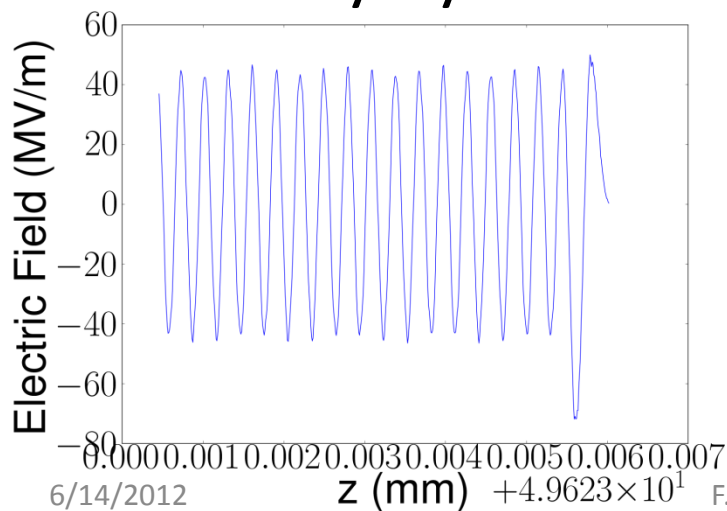
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# Advanced Superconducting Test Accelerator (ASTA)



# DLW Acceleration at ASTA

- Flexible bunch shaping capabilities
  - Round, flat,
  - longitudinally tailored(p2)
- High repetition rate
  - Study dynamical effects



# Conclusions

- What's beyond the standard model?
  - Let's make a PeV machine!
- Light sources have long waiting lines!
- “Recycle”



SUSY