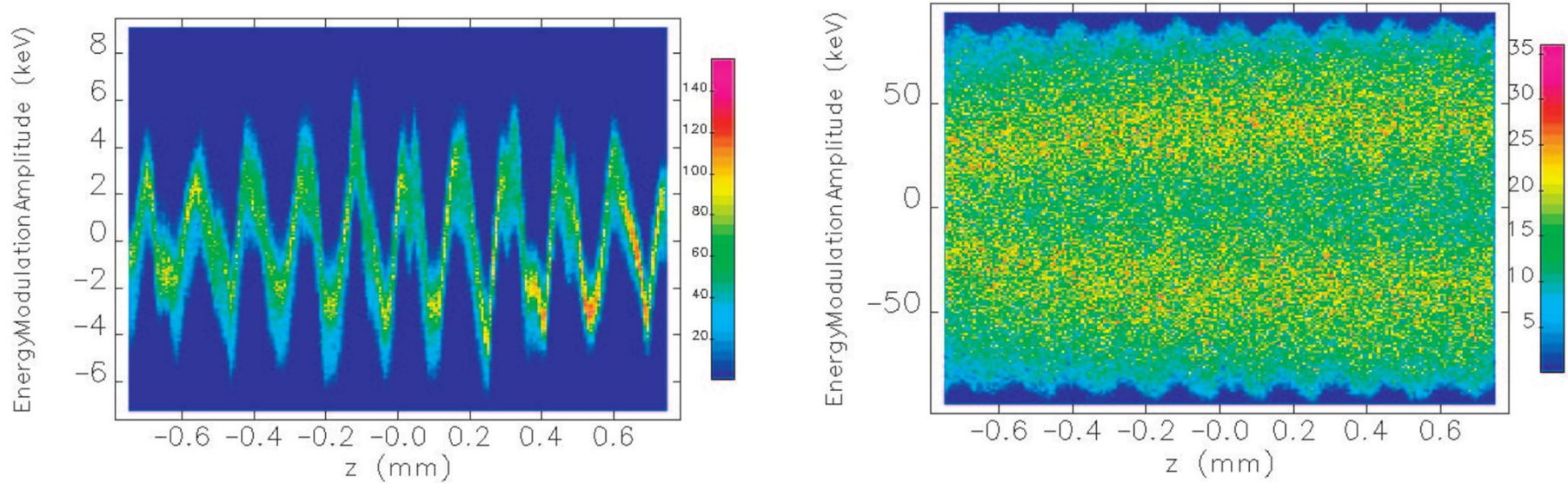


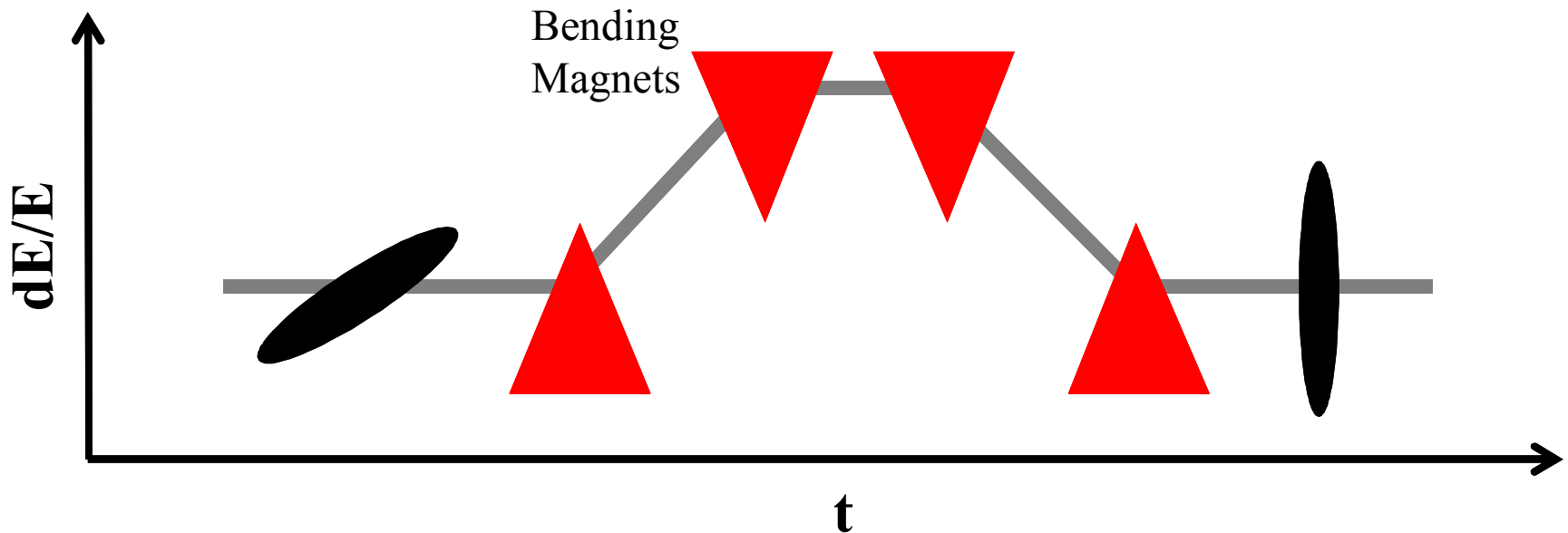
# Laser Heaters



Zhen Wang  
Ahmed AbuAli  
Donish Khan  
Lipi Gupta  
August 7<sup>th</sup>, 2015  
SSSEPB 2015

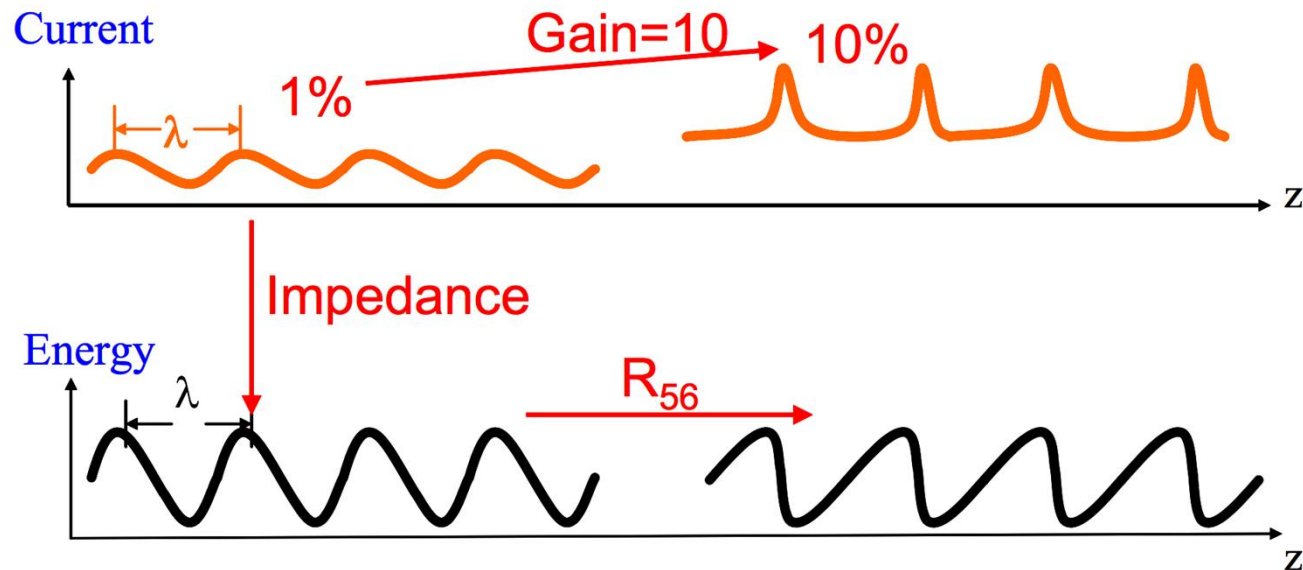
# Bunch Compressor

- Increases slice energy spread (increase peak current)
- Consists of 4 bending magnets:
  - Compresses in longitudinal phase space



# Microbunching Instability

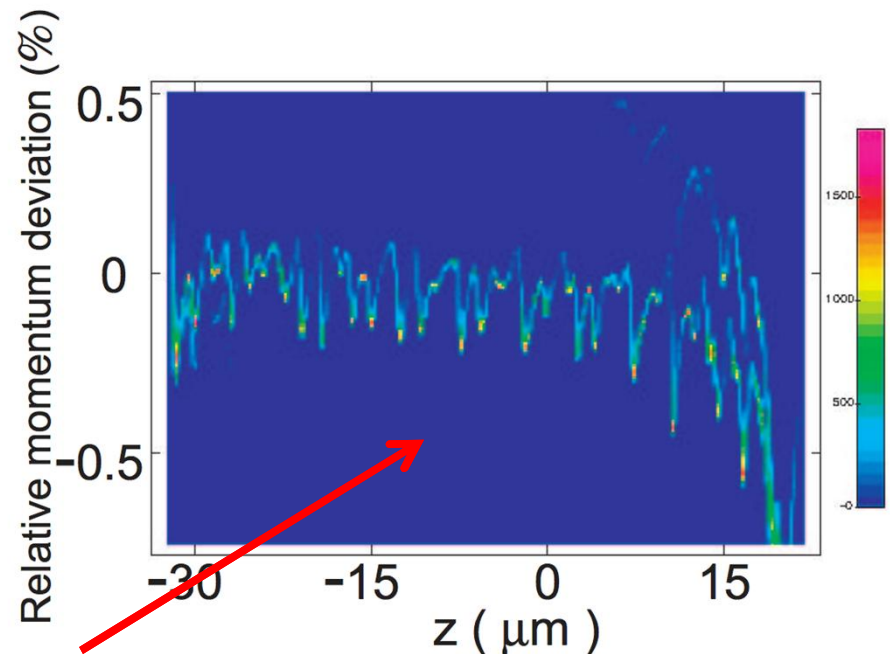
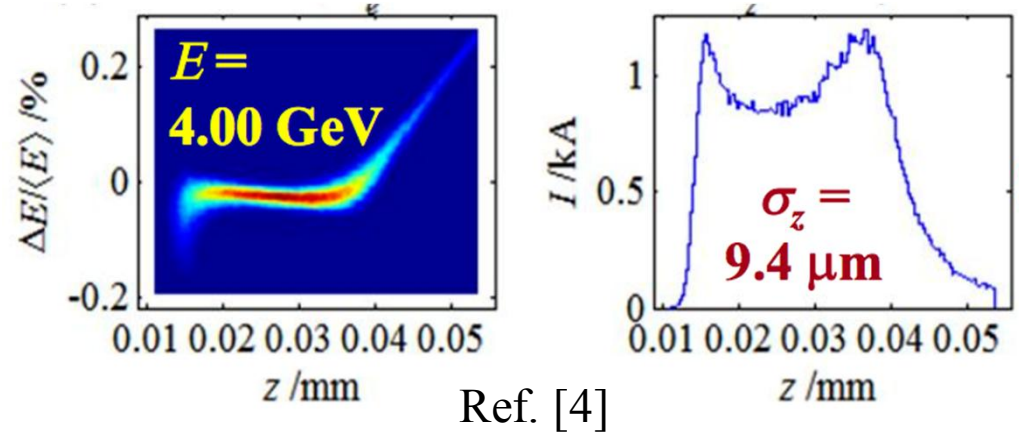
- What is it?
  - Self-developing density modulations within a bunch
- Comes from CSR in the chicane
  - Initial density modulation creates energy modulation due to LSC
  - After chicane, density modulation is “exchanged” for energy modulation



# Microbunching Instability cont.

Why is microbunching bad?

It degrades beam quality  
and thus the quality of  
the radiation produced by  
the FEL process!



Initial density modulation = 8% at 150  $\mu\text{m}$

Ref. [3]

# Microbunching Instability cont.

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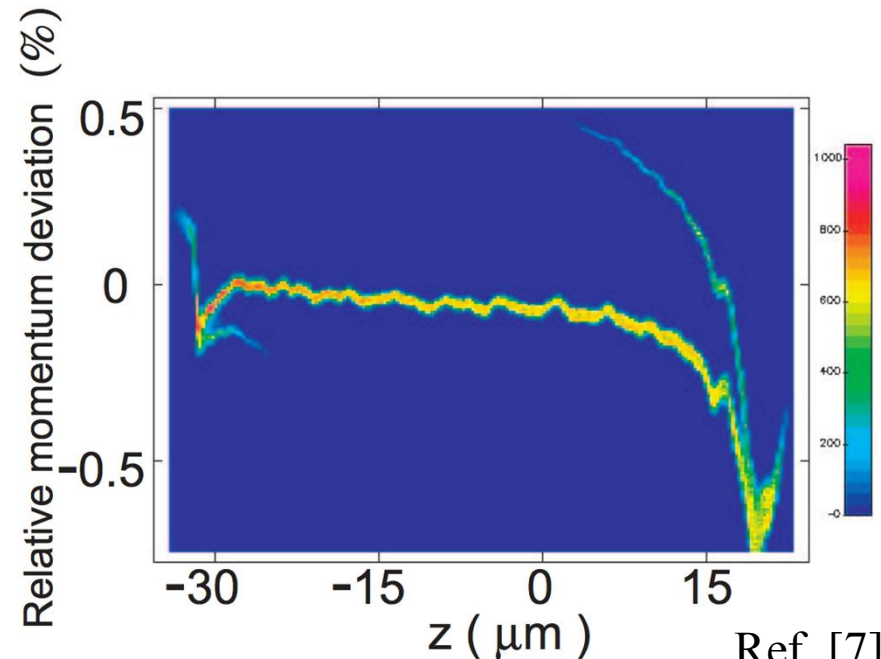
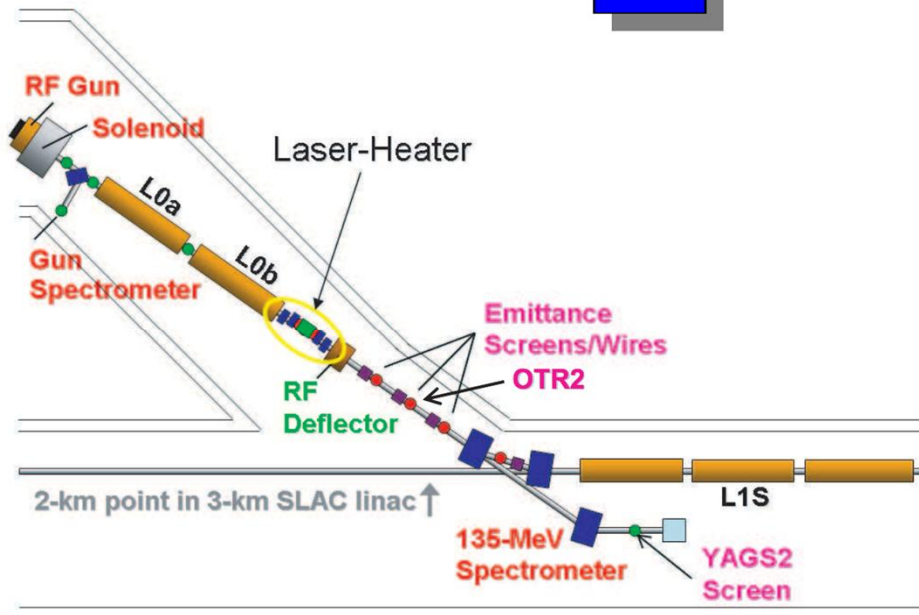
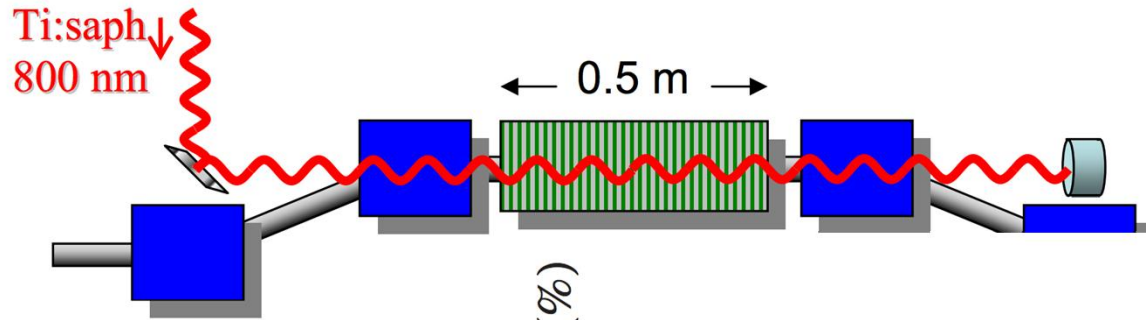
How can we suppress this phenomena?

$$G = \left| \frac{b_f}{b_0} \right| \approx \frac{I_0}{\gamma I_A} \left| k_f R_{56} \int_0^L ds \frac{4\pi Z(k_0; s)}{Z_0} \right| \\ \times \exp\left(-\frac{1}{2} k_f^2 R_{56}^2 \sigma_\delta^2\right) S_L[k_f R_{56} \delta_L(0), \sigma_r / \sigma_x],$$

Gain in density modulation is sensitive to the slice energy spread (SES)

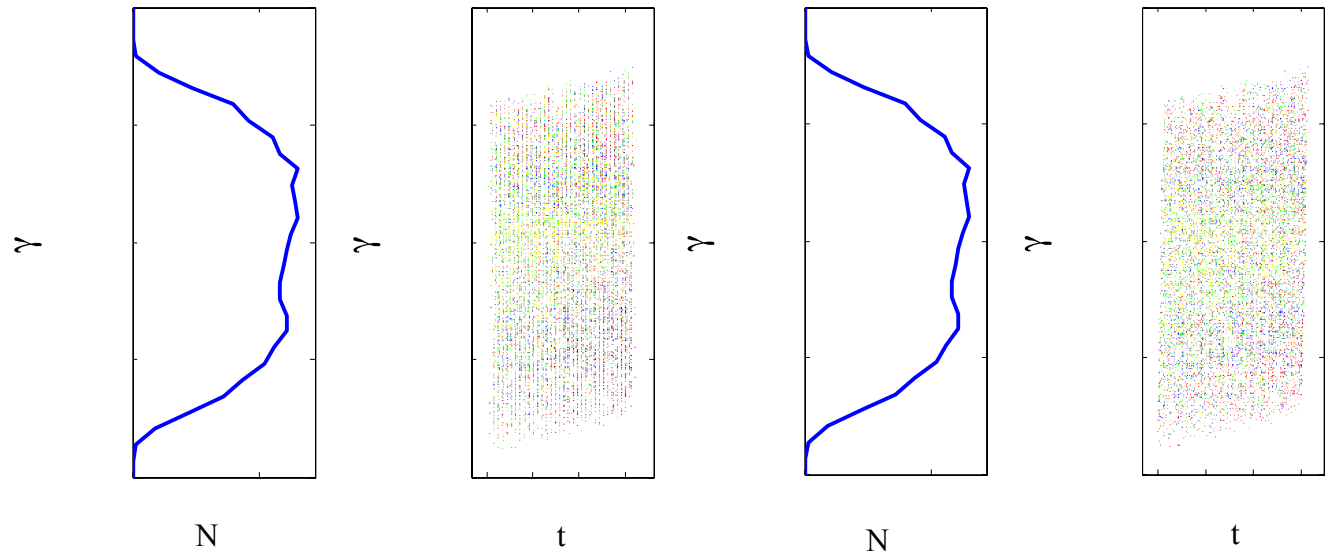
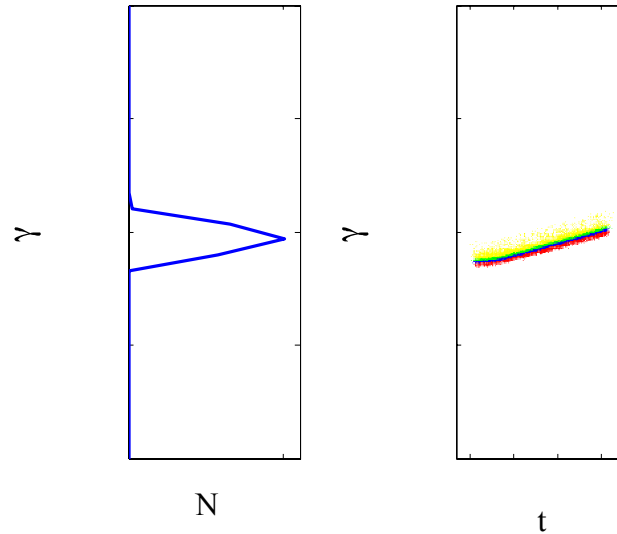
# Laser Heater

- 800 nm laser, increases energy modulation in undulator section of magnetic chicane
  - Increases slice energy spread



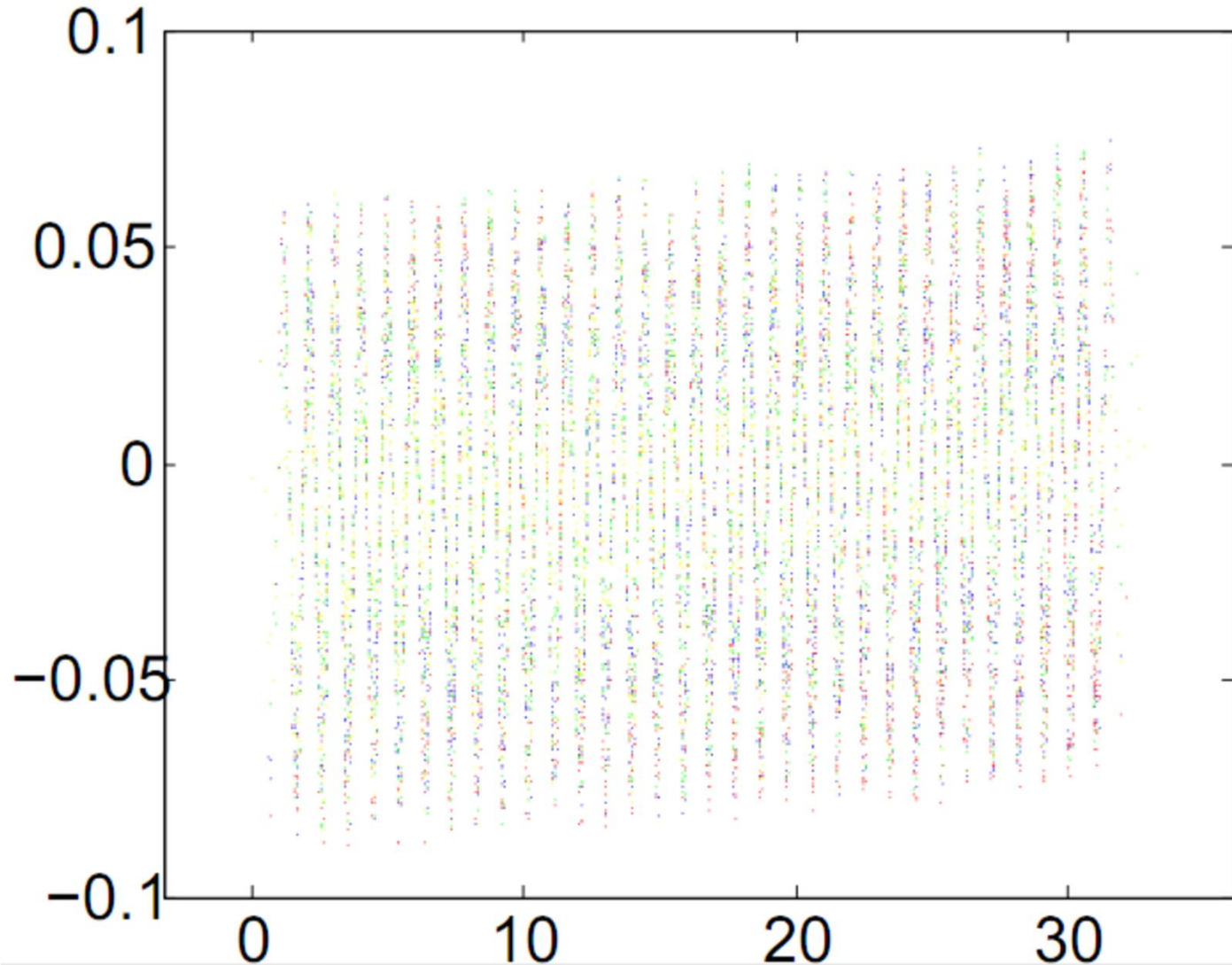
# Laser Heater Mechanism

- Laser spot size is comparable to transverse electron beam size
- Energy modulation is close to Gaussian distribution



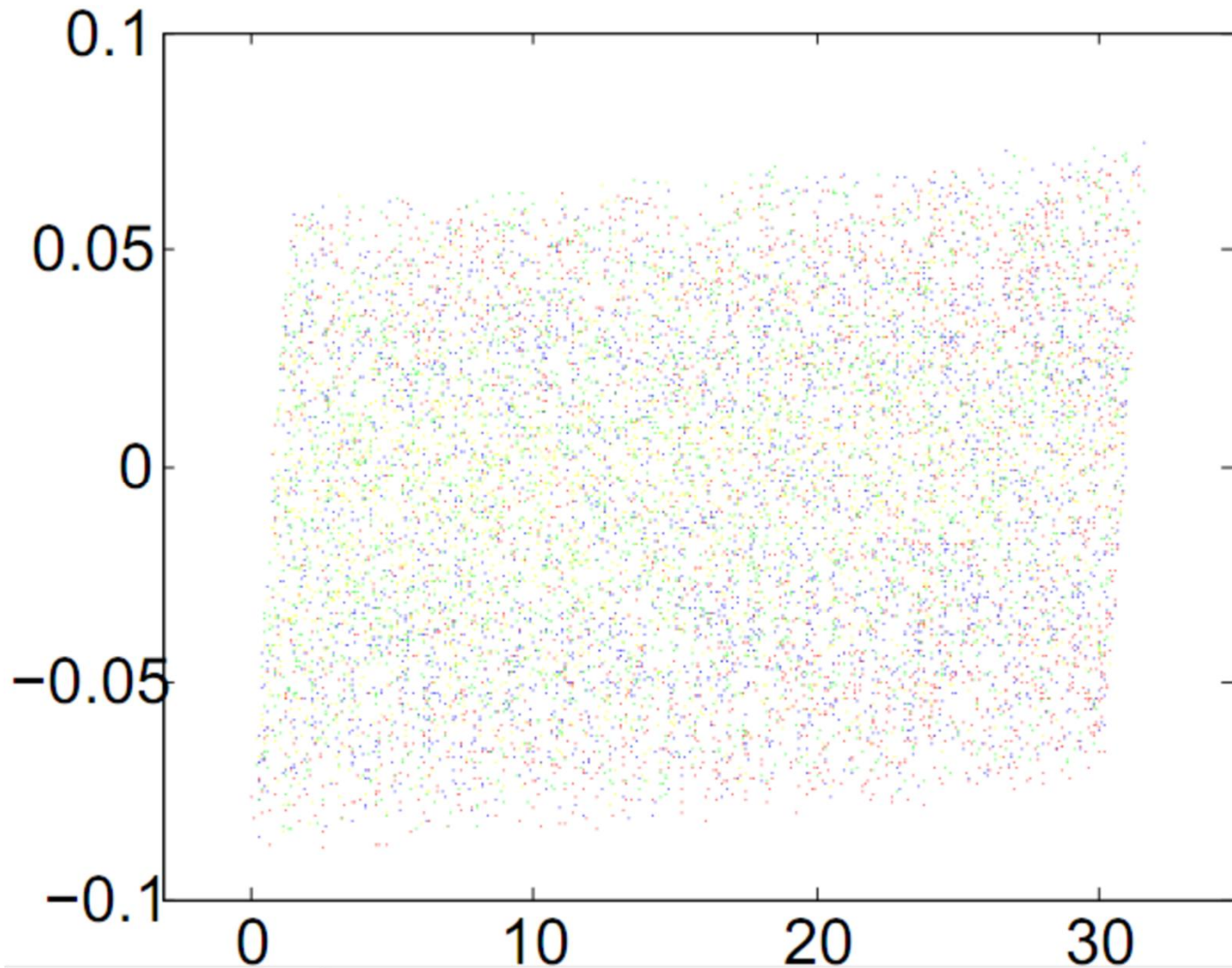


# Laser Heater Mechanism



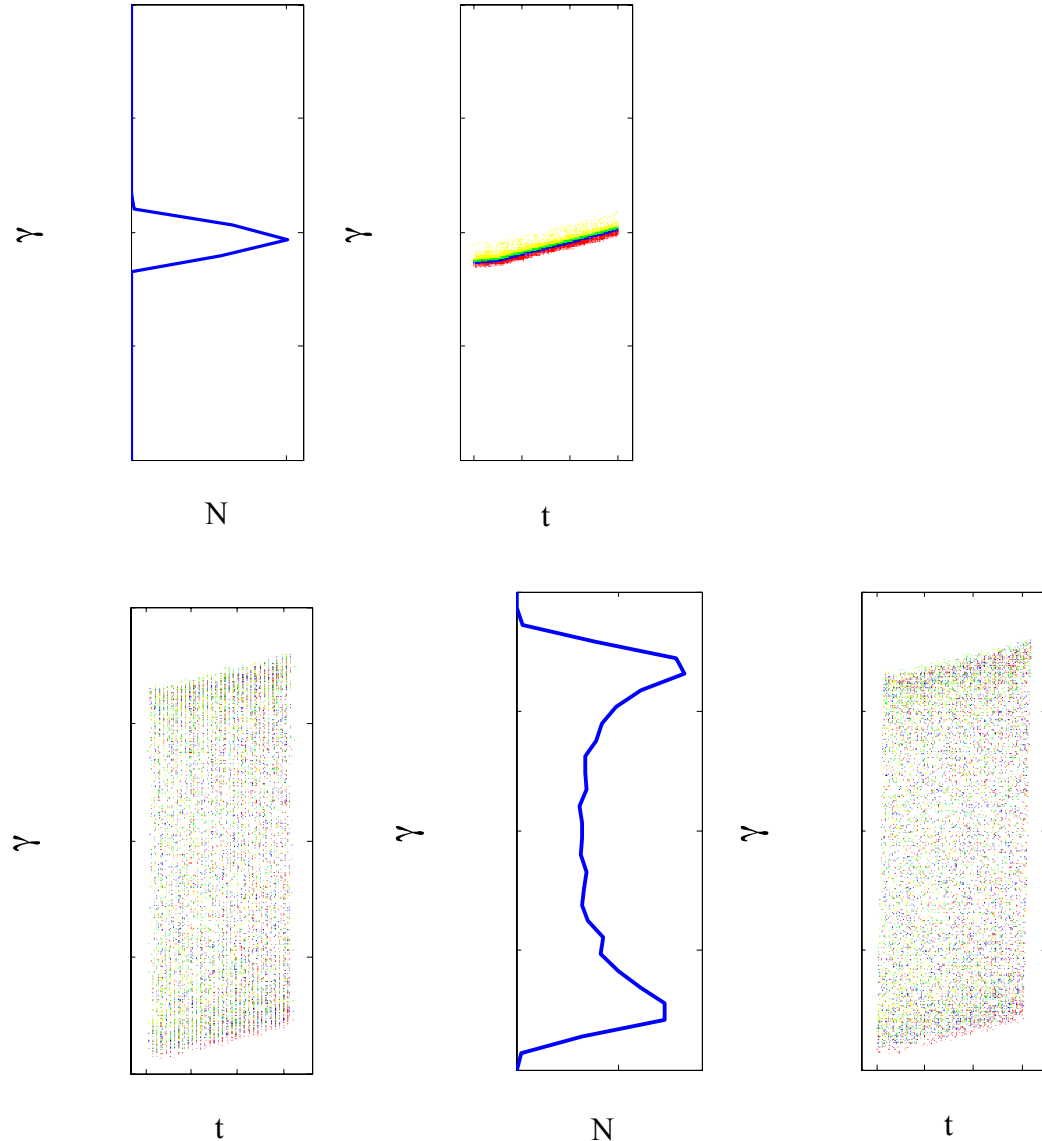


# Laser Heater Mechanism

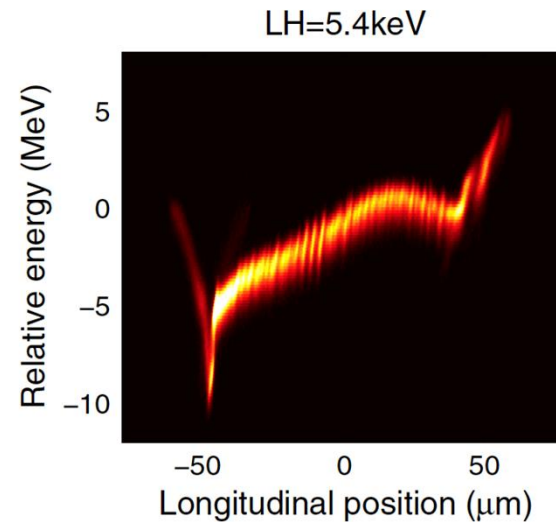
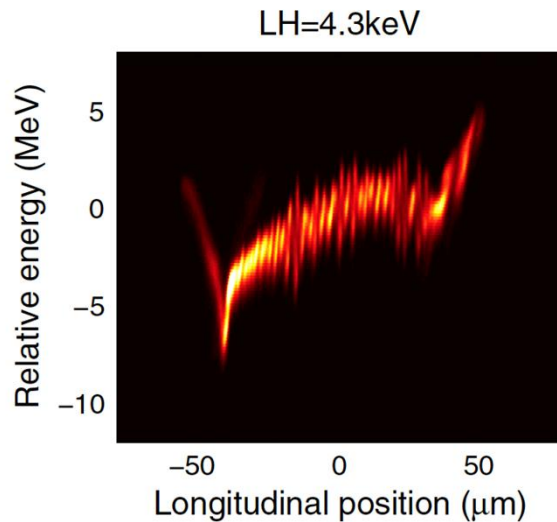
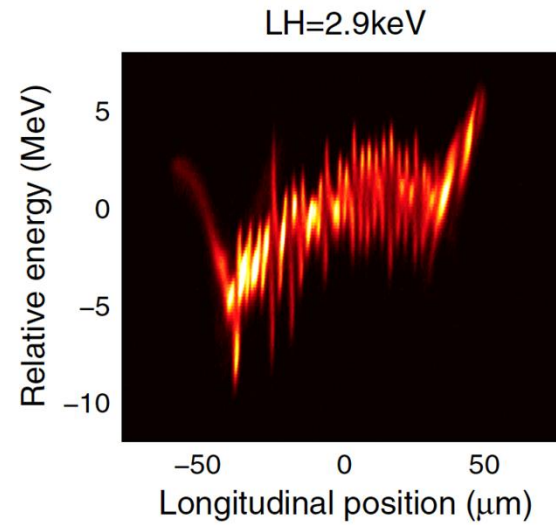
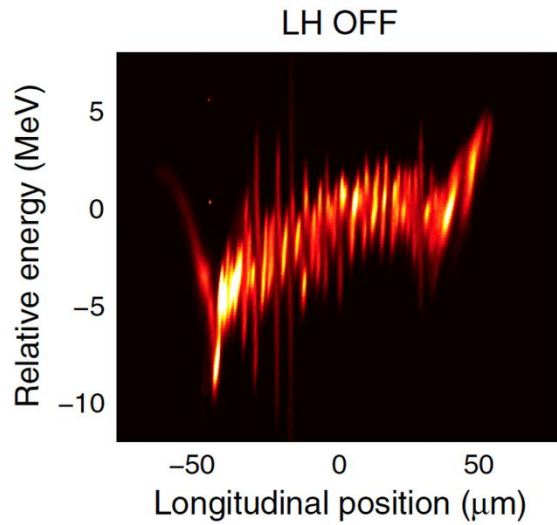


# Laser Heater Mechanism

- Laser spot size is 3 times bigger than transverse electron beam size
- Double horn energy modulation is non-ideal
- See Ref.[5] for details

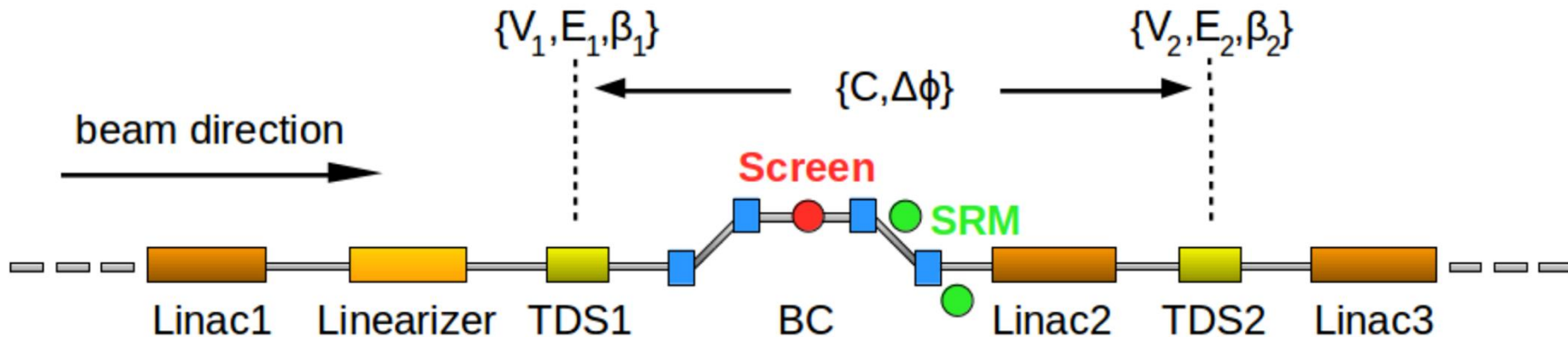


# Laser Heater cont.

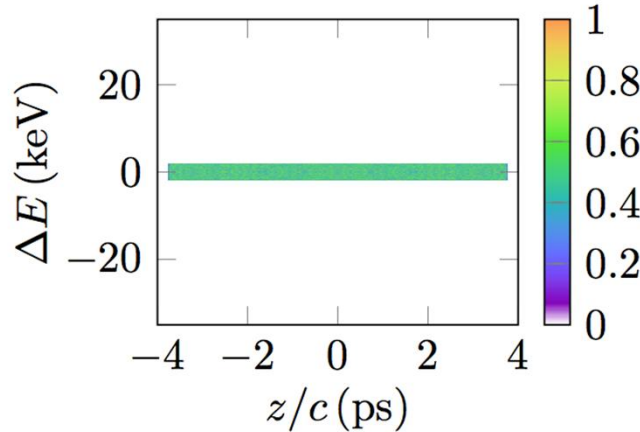


# Reversible Heater

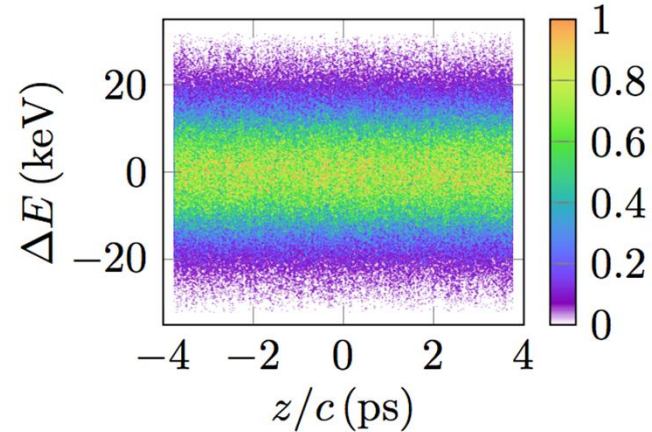
- Transverse deflector RF structure provides transverse energy chirp
  - Transversely correlated energy spread can be compensated in downstream TDS



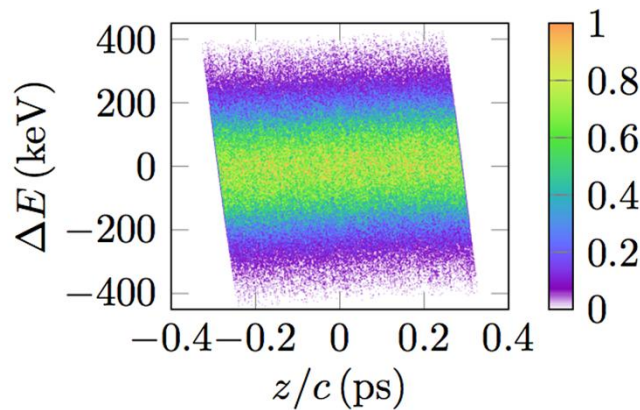
# Reversible Heater



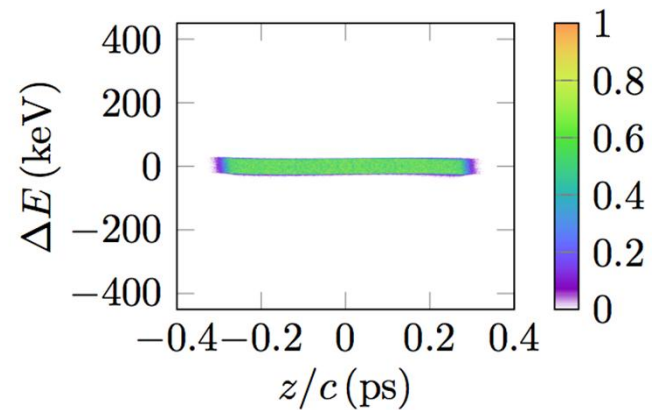
(a) Upstream of TDS1.



(b) Downstream of TDS1.



(c) Upstream of TDS2.



(d) Downstream of TDS2.

# Laser Heater vs. Reversible Heater

## **Advantage of Laser Heater:**

Simple solution (as compared to the reversible heater mechanism) and is effective for SASE FELs

## **Disadvantage of Laser Heater:**

- (1) Increased SES cannot be/is not compensated later in the lattice
- (2) Limits the effectiveness of FEL processes such as self-seeding

## **Advantage of Reversible Heater:**

Increased SES is compensated for after bunch compression

## **Disadvantage of Reversible Heater:**

Vertical emittance degradation due to CSR during the bunch compression process

# References

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1. C. Behrens, Z. Huang and D. Xiang, Phys. Rev. ST Accel. Beams 15, 022802 (2012).
2. D. Ratner, et al., Phys. Rev. ST Accel. Beams 18, 030704 (2015).
3. J. Wu et al., SLAC-PUB-10430, 2004.
4. T. Raubenheimer, “Linacs and Bunch Compressors,” SSSEPB Lecture 2, 2015.
5. Z. Huang et al., Phys. Rev. ST Accel. Beams 7, 074401 (2004).
6. Z. Huang et al., Phys. Rev. ST Accel. Beams 13, 020703 (2010).
7. Z. Huang et al., SLAC-PUB-13854.