Experimental Observation of Energy Modulation in Electron Beams Passing Through Terahertz Dielectric Wakefield Structures

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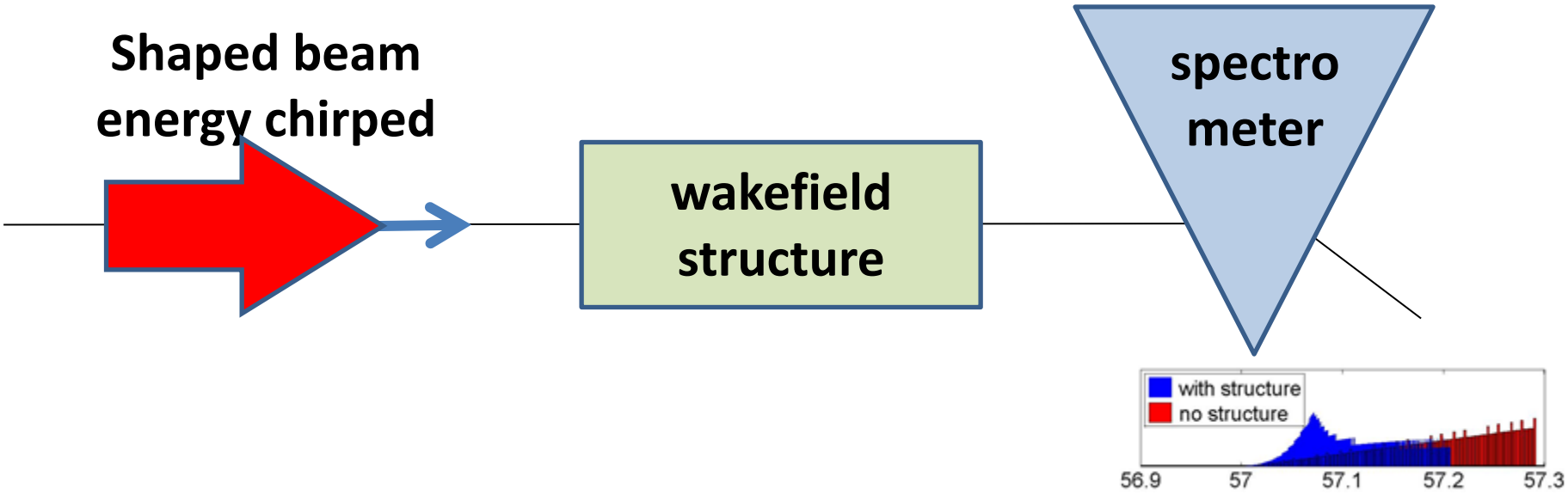
ATF Program Advisory Committee and the ATF Users' Meetings, April 26 - 27, 2012

Experiment outline

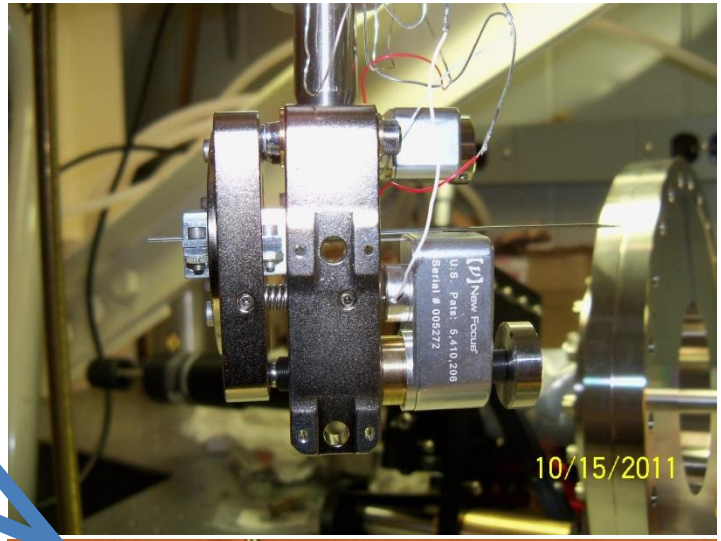


Shape + energy chirp → energy change via self-wakefield

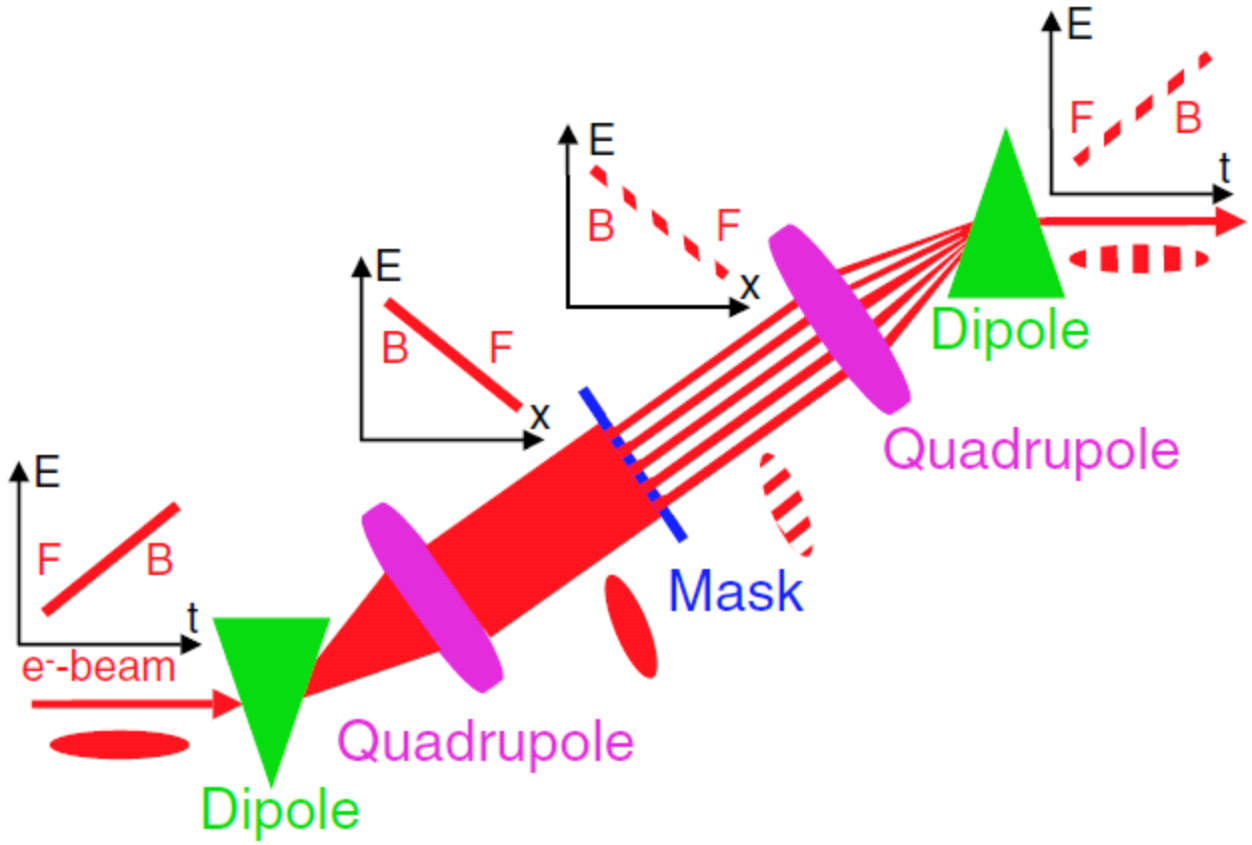
- Self-wake energy chirp compensation
- Self-wake energy modulation

Structures

- Quartz tubes (ε = 3.8)
- Gold plated
- Inserted into SS tubes
- Placed in the holder
- Sizes:
- 1”, 200 x 330 μ^2
- 1”, 300 x 400 μ^2
- 2” and 4”, 400 x 550 μ^2



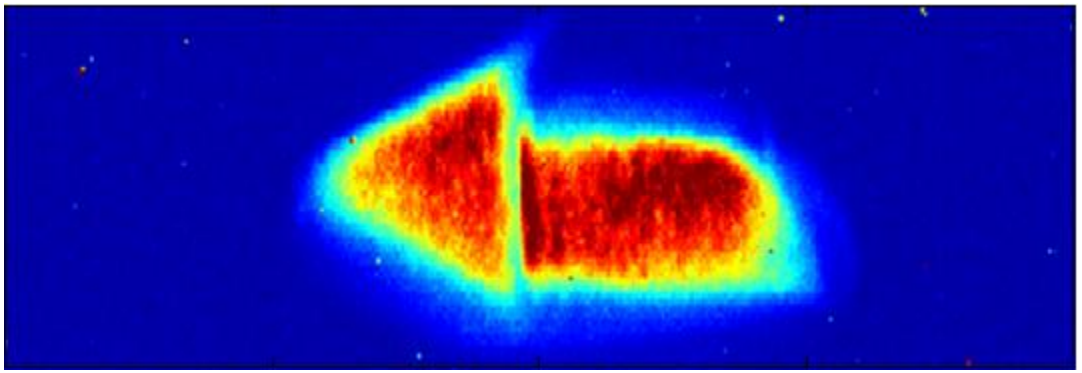
ATF beam masking



P. Muggli et al. Phys. Rev. Lett. 101, 054801 (2008)

ATF beam shaping

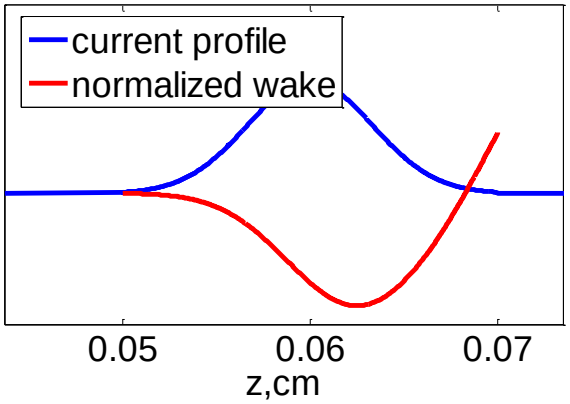
Image on the spectrometer

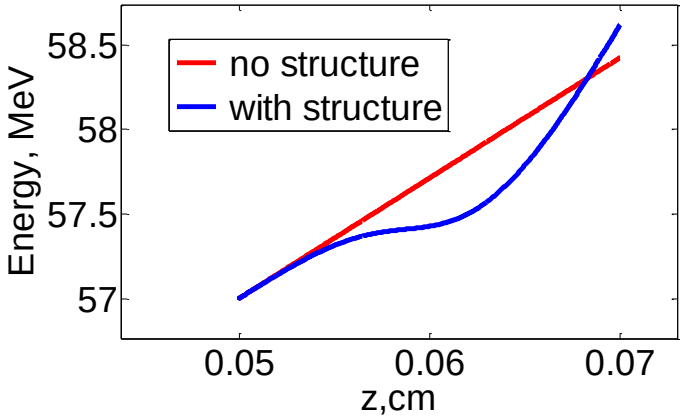


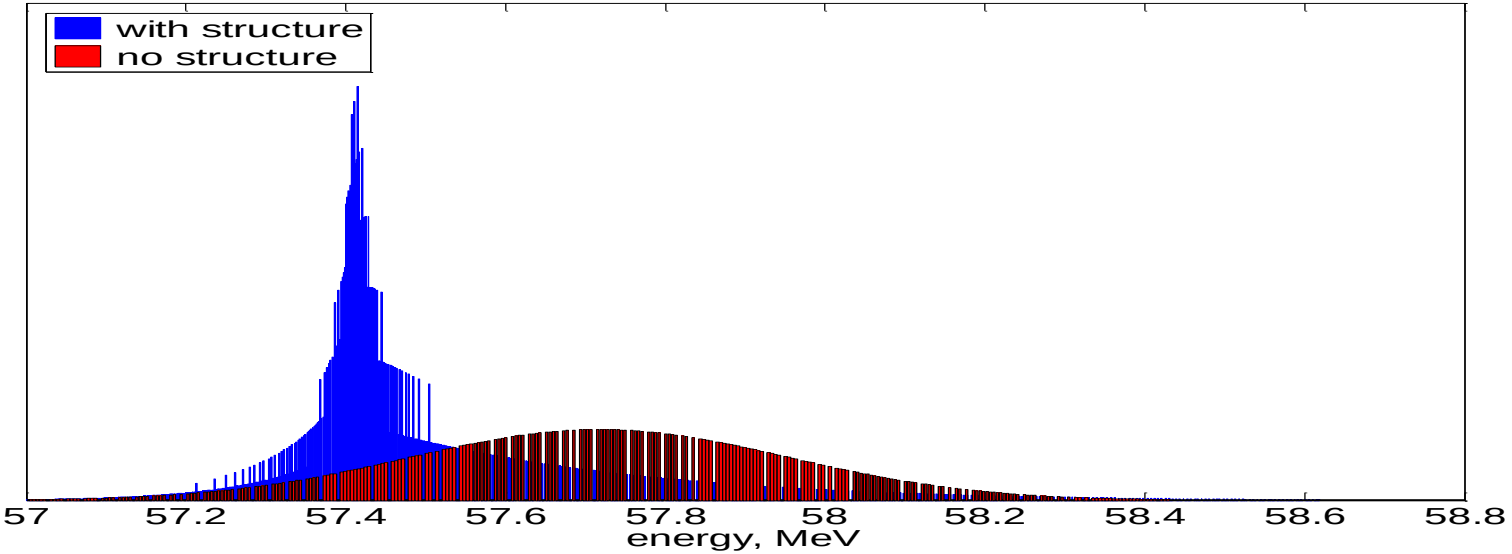
energy

- "Arrow" mask → shaped beam with energy chirp
- High energy slits to change shape (pure triangle beam) + drive-witness window
- IPOP3 (screen after the mask) to longitudinal size calibration via CTR interferometry
- Dispersionless beamline → shape shows up on the spectrometer

Energy chirp correction; gaussian

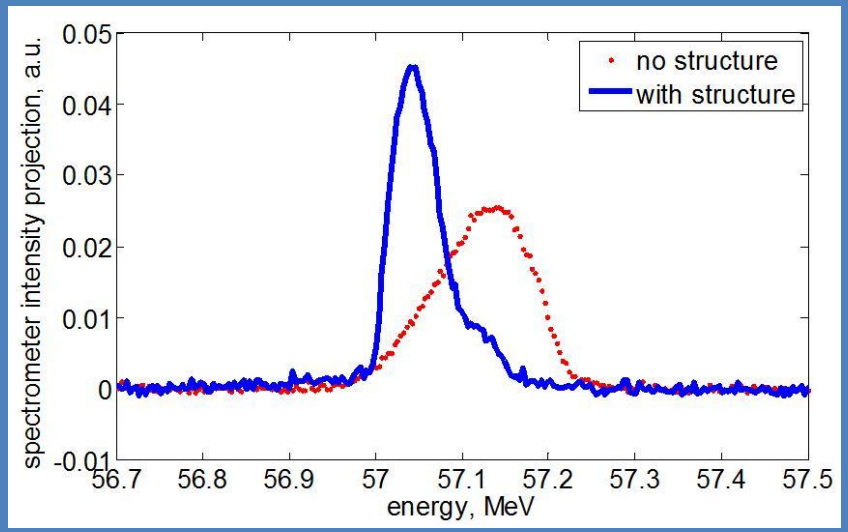






Energy chirp correction at ATF

measurement



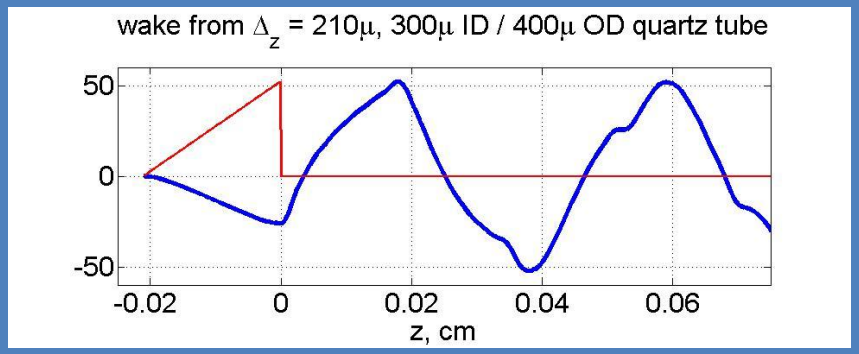
Limited by spectrometer resolution; Beam transmission

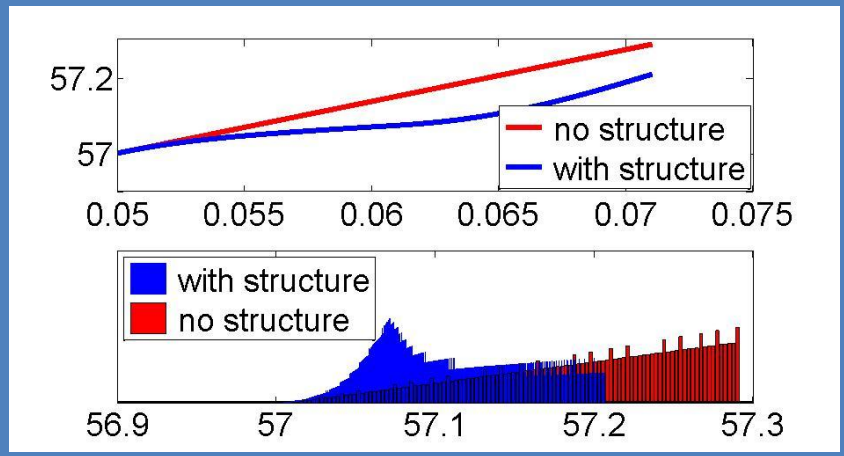
Quartz tube (ε = 3.8)

(Gold sputtered + SS housing)

Size (ID / OD): 1”, 300 x 400 μ

simulation

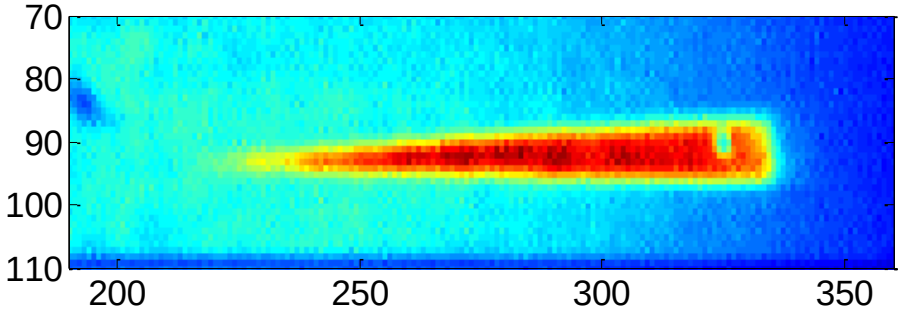




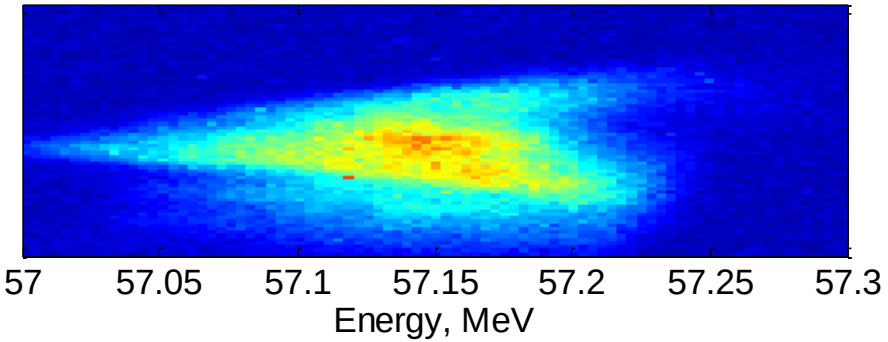
Linear chirp correction / energy modulation

Energy chirp compensation measurement

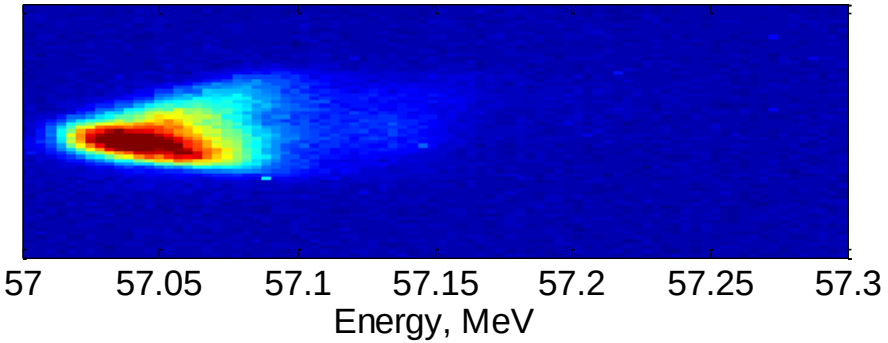
beam image after the mask, triangle length is 247 micron



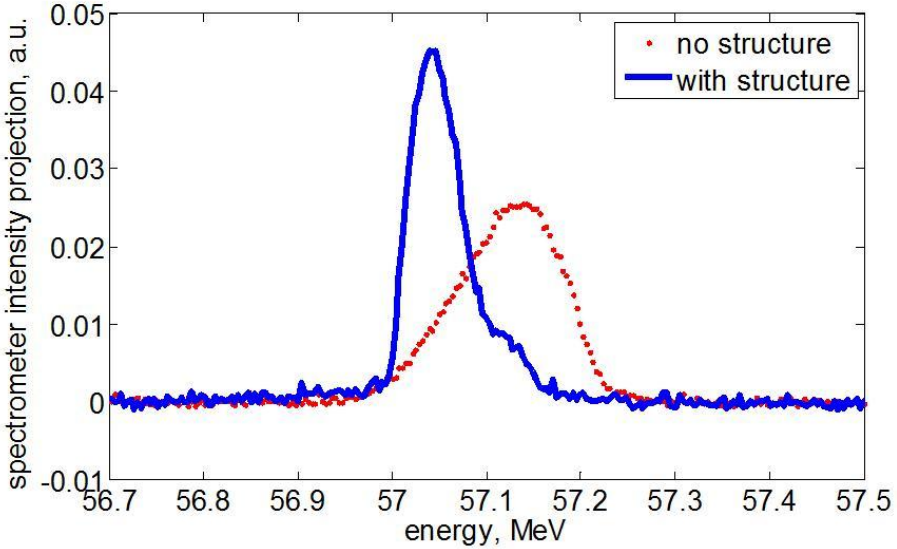
spectrometer image of unperturbed beam

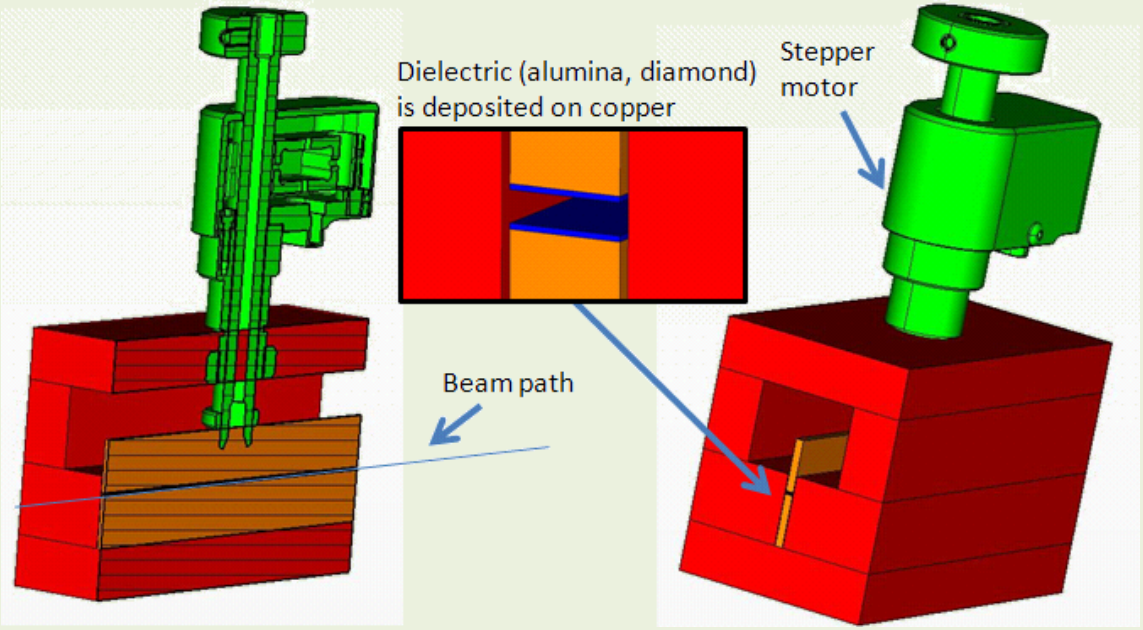


spectrometer image of a beam that passed through the structure



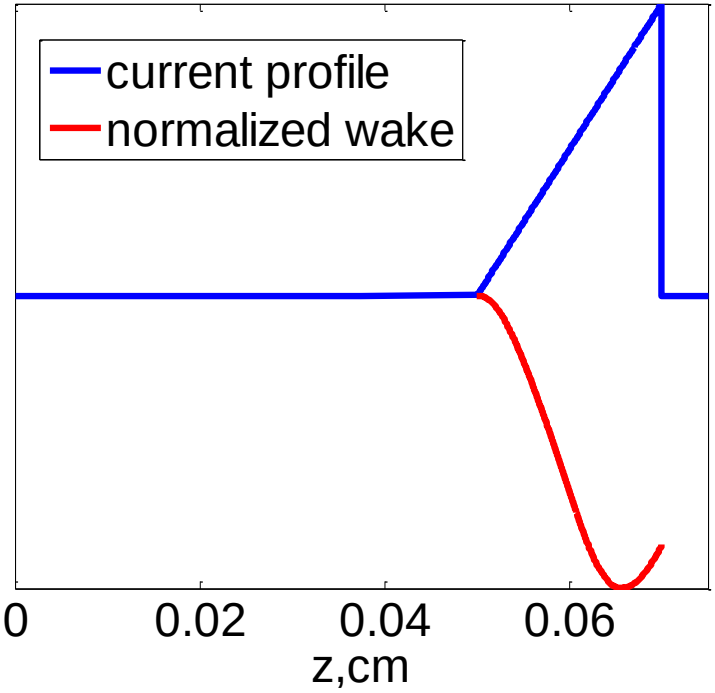
Spectrometer image projection

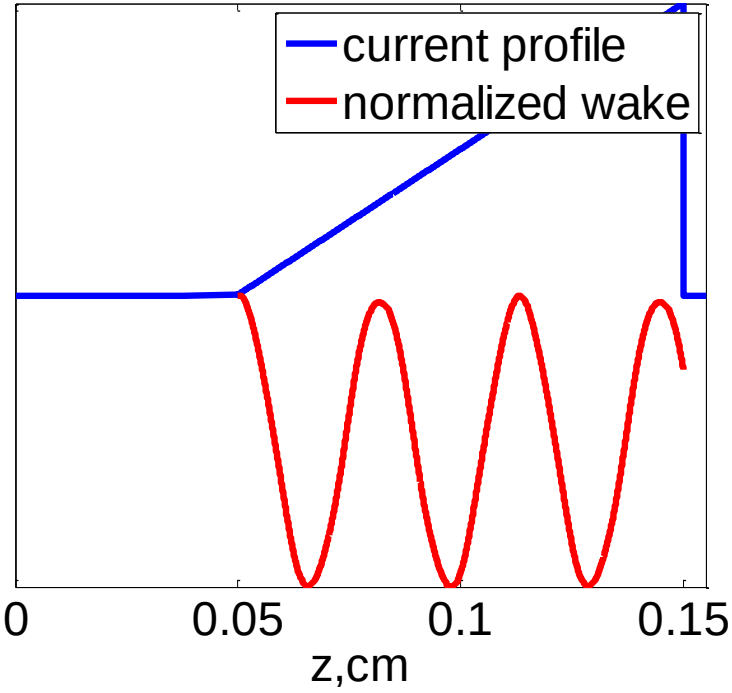




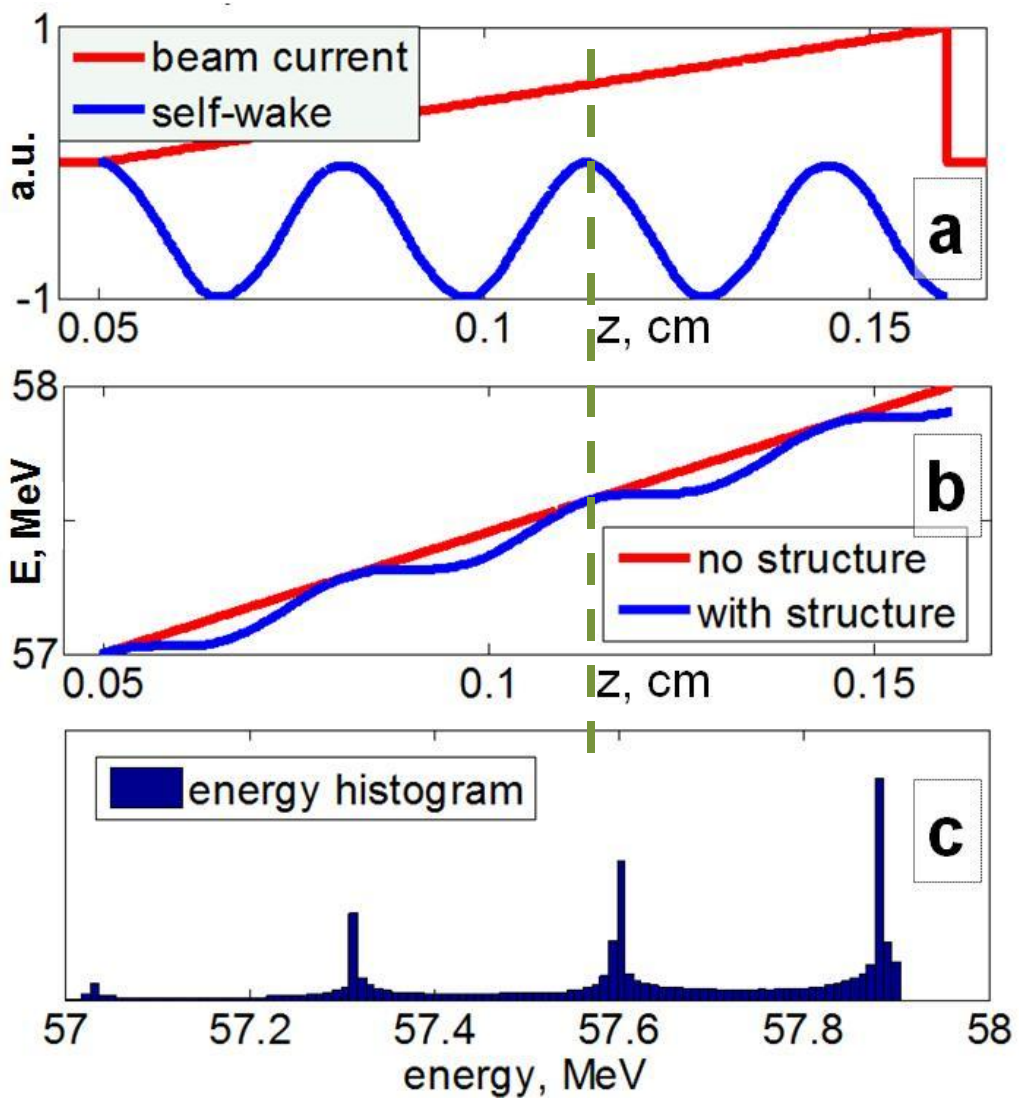
PROPOSED EXPERIMENT: TUNABLE ENERGY CHIRP COMPENSATION

Energy modulation

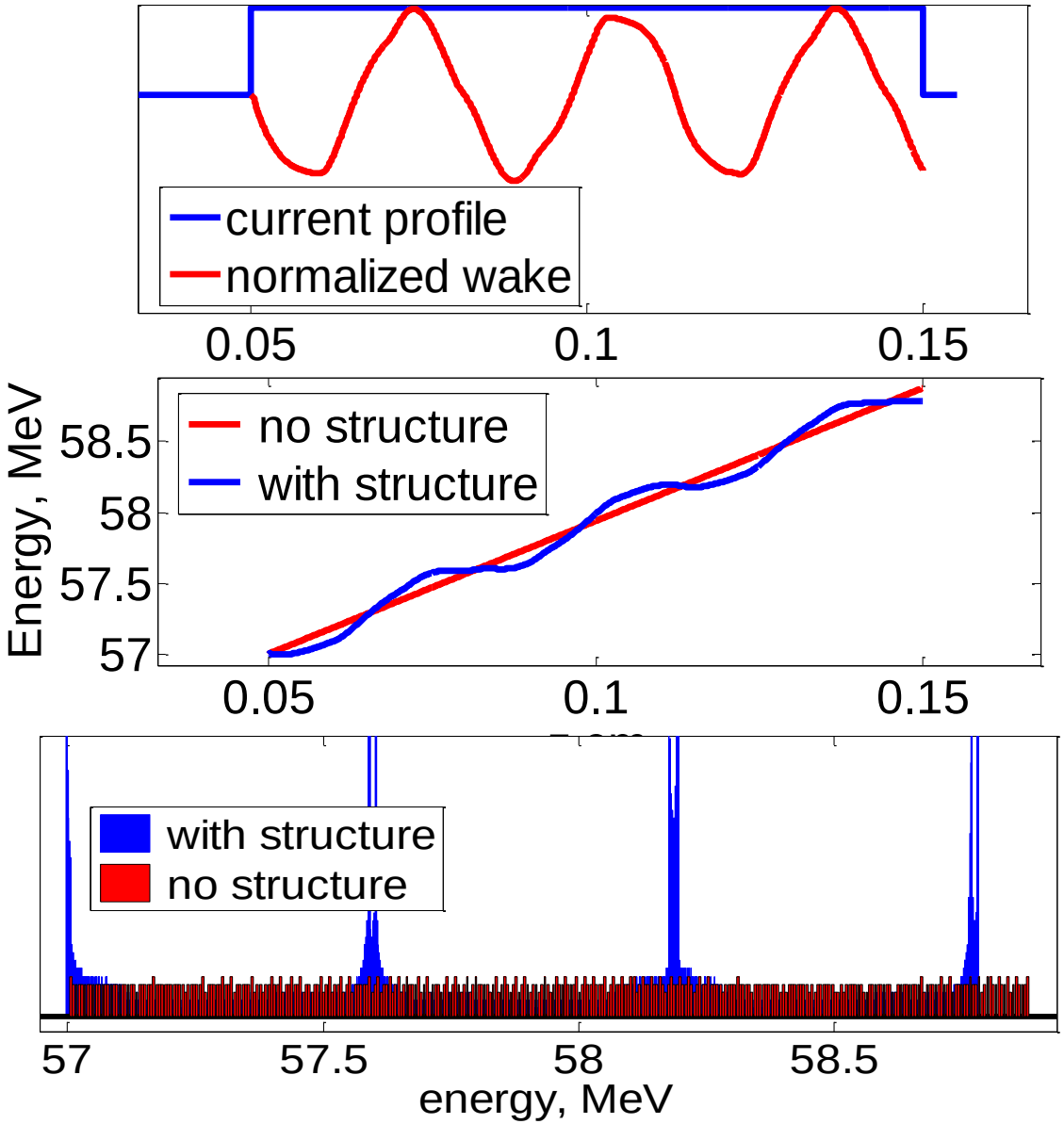




Energy modulation in triangular beam



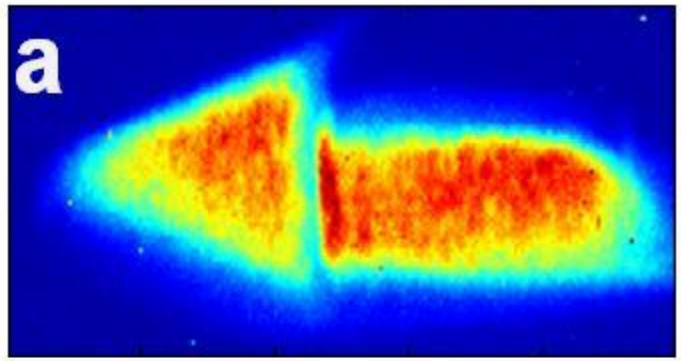
Energy modulation in rectangular beam

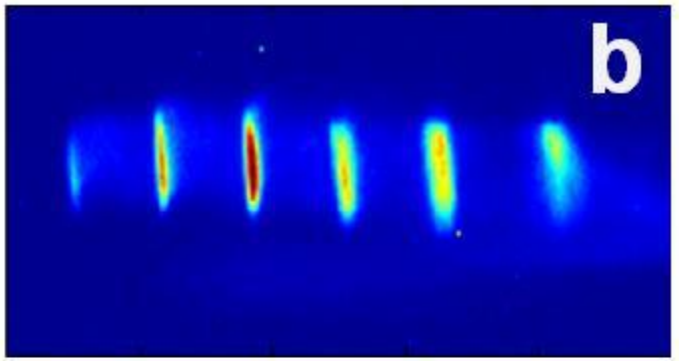


Energy modulation observed

Spectrometer images

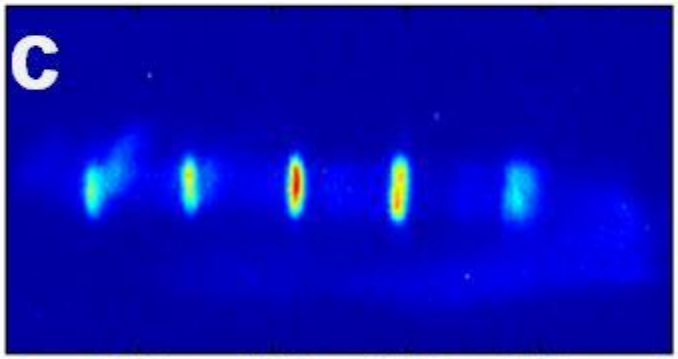
As is: No structure

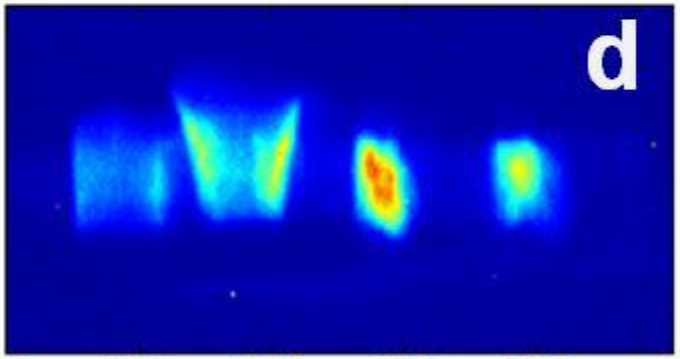


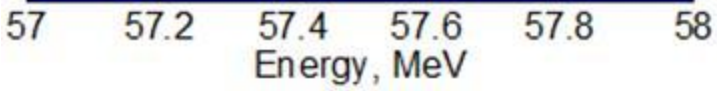


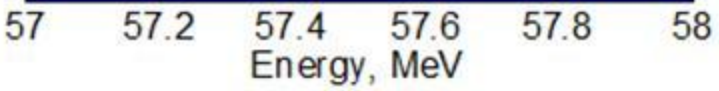
0.95 THz structure

0.76 THz structure





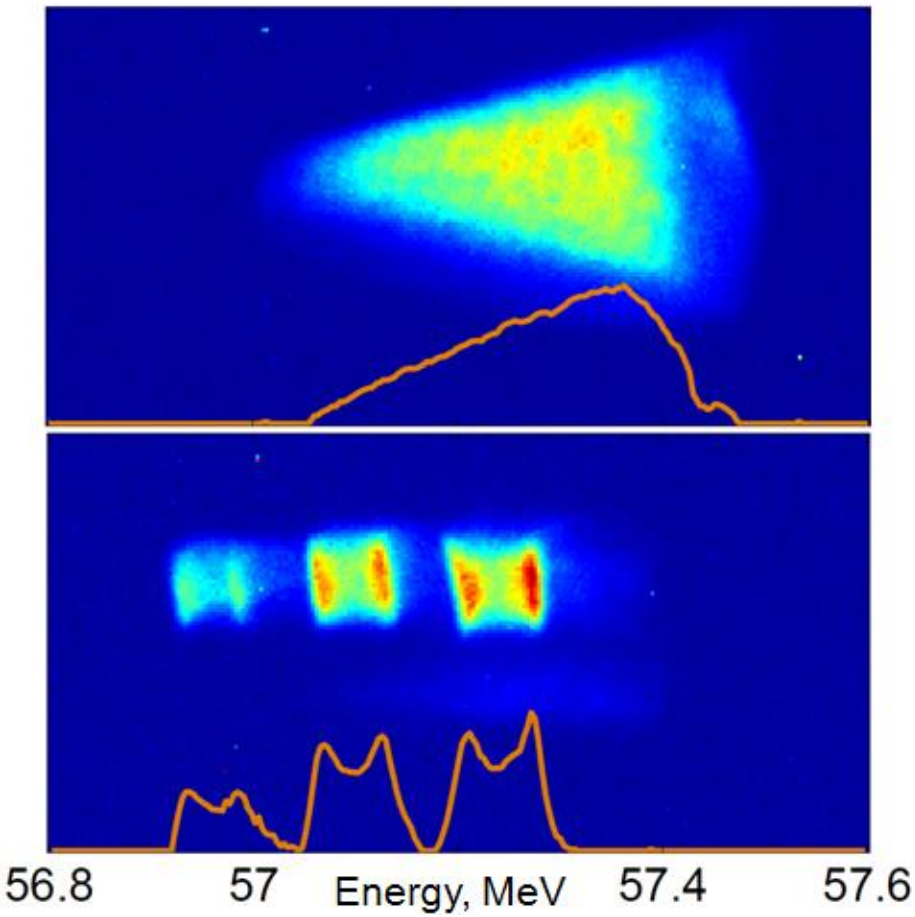


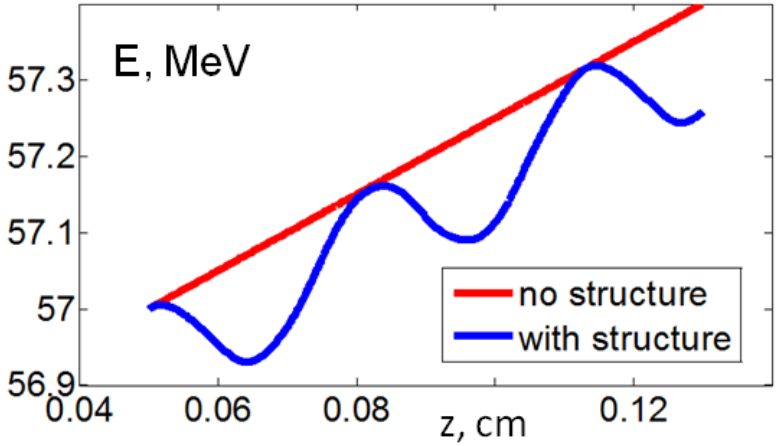


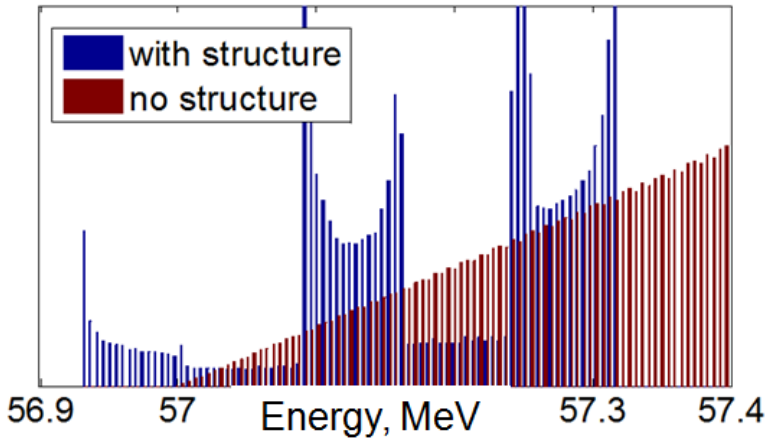
0.615 THz structure

S. Antipov et. al. Phys. Rev. Lett. 108, 144801 (2012)

Over-modulation observed

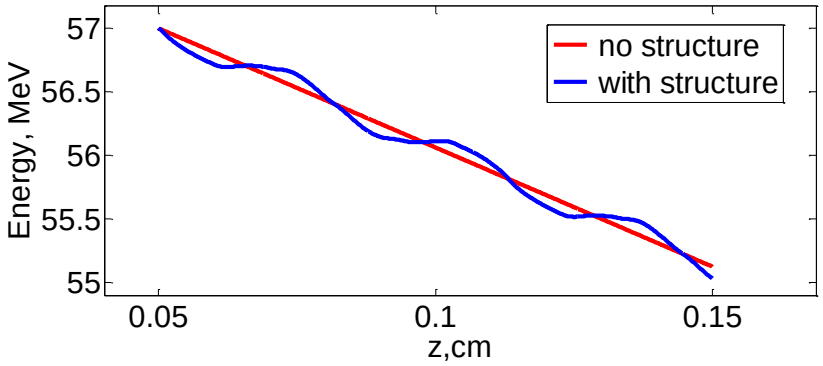


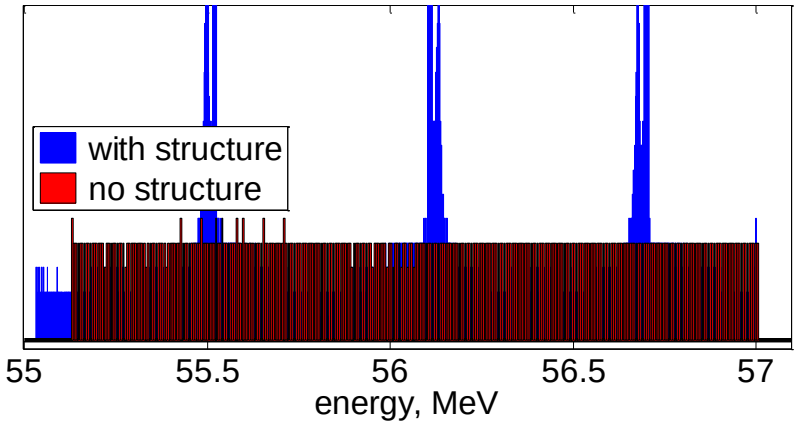




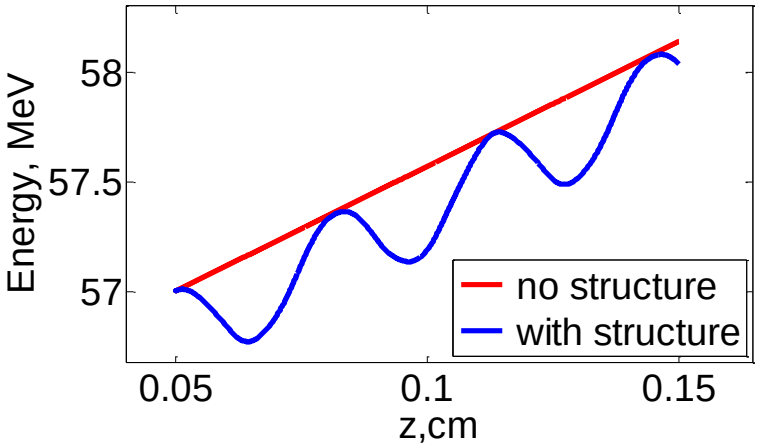
Few other (theoretical) examples

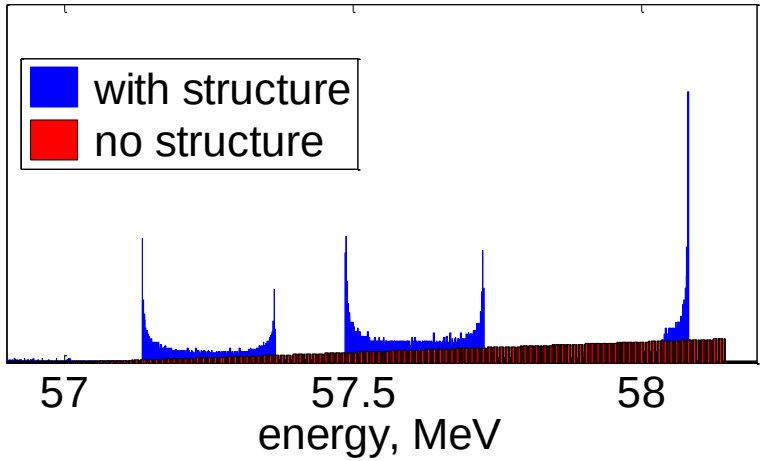
Energy modulation in rectangular beam, negative energy chirp

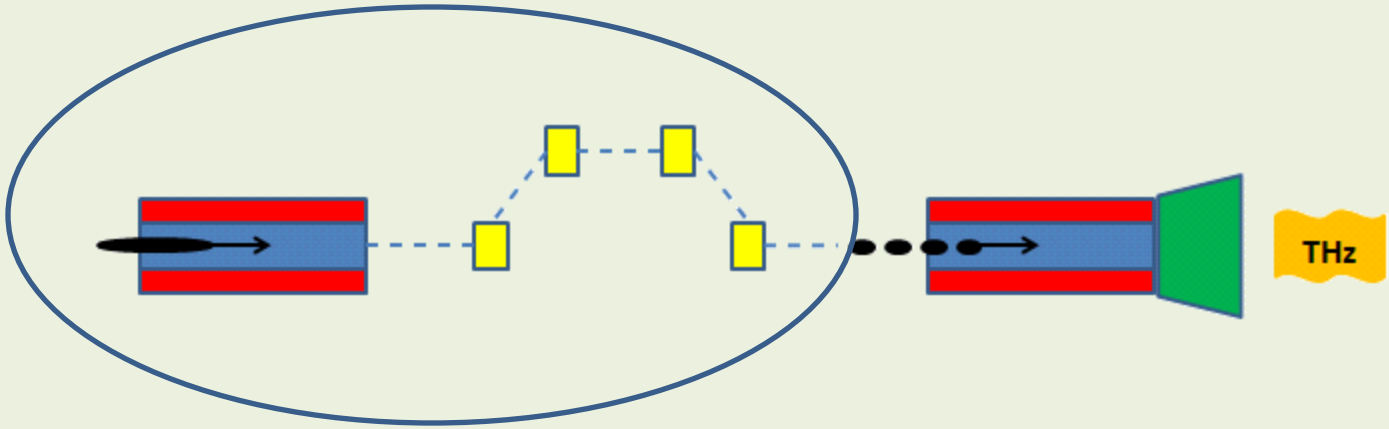




Over modulation in triangular beam, positive energy chirp







PROPOSED EXPERIMENT: ENERGY MODULATION CONVERSION TO A BUNCHTRAIN FOR THZ SOURCE