Beam manipulation by self-wakefield at ATF

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ATF Program Advisory Committee and
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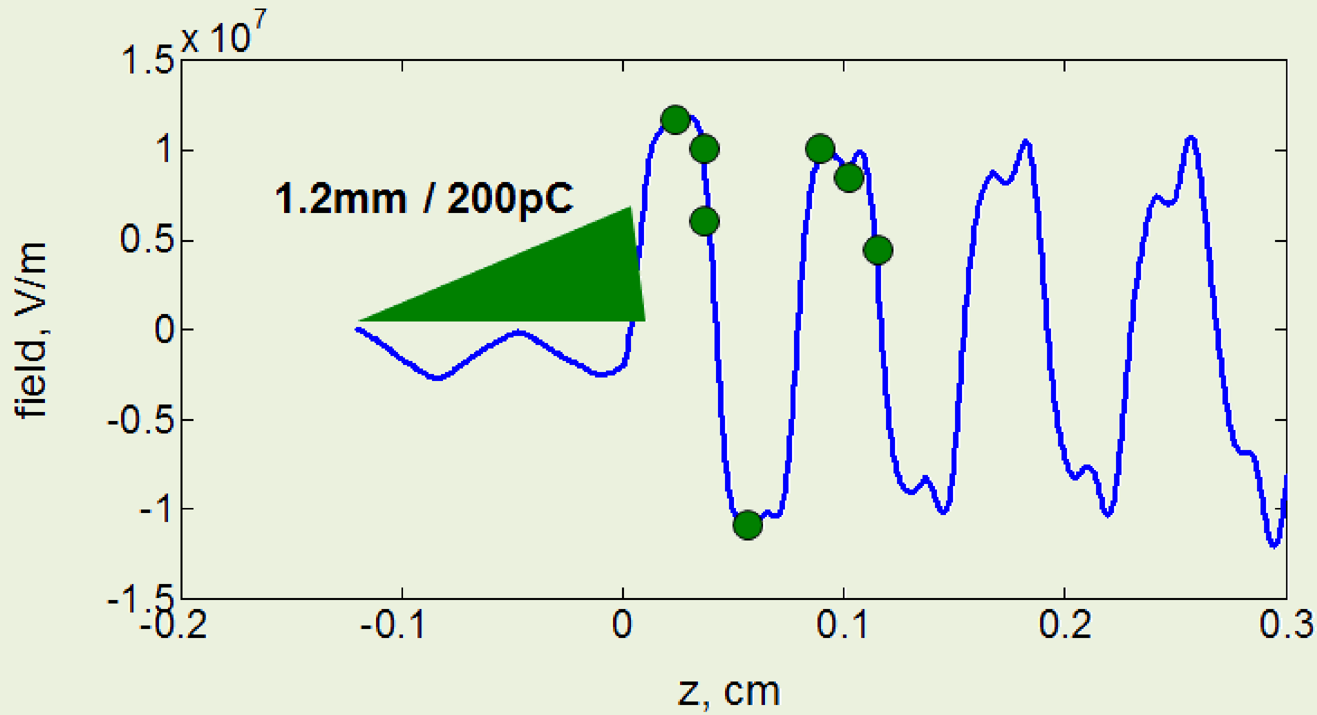
Outline

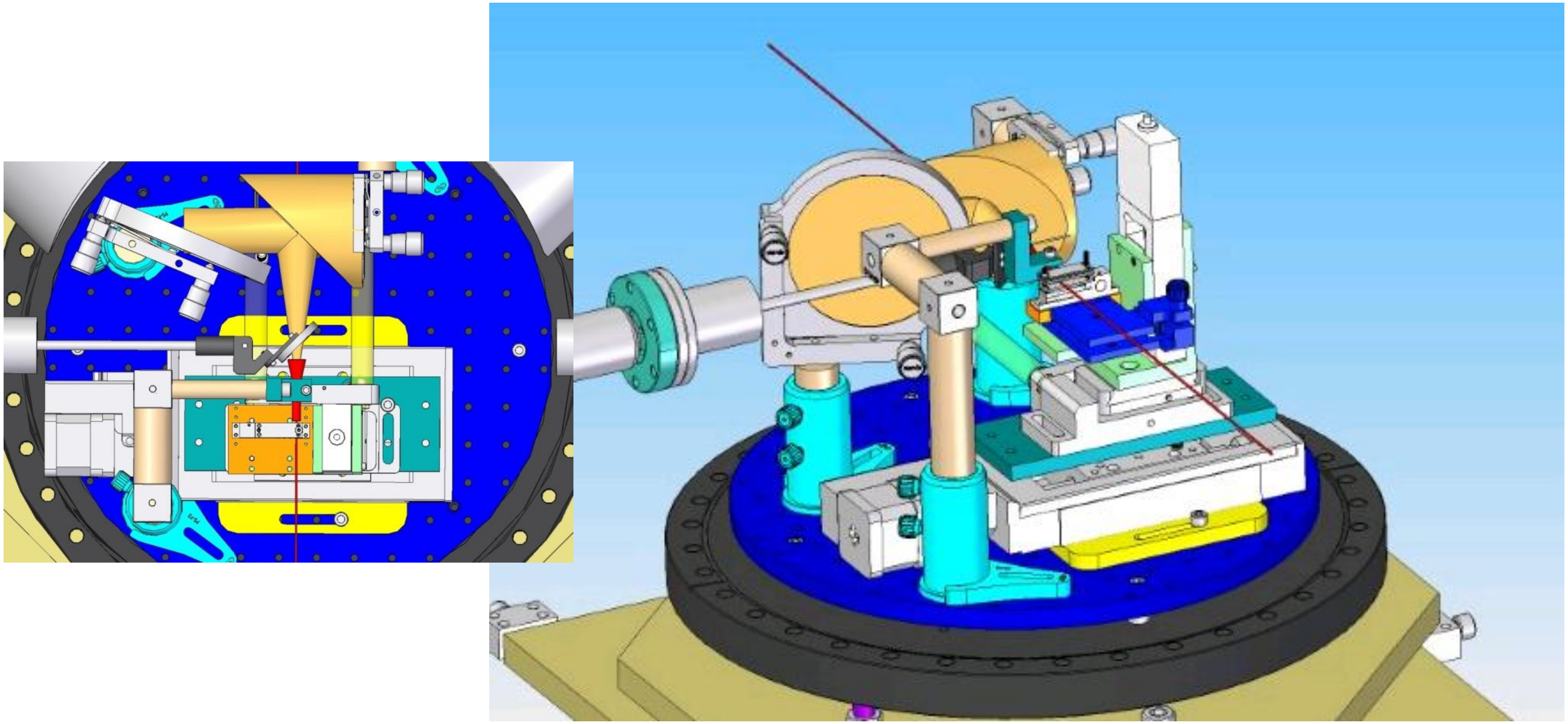
1. Enhanced Transformer Ratio demonstration (wakefield mapping with the shaped beam)
2. Tunable beam energy chirp compensator
3. Conversion of self-wake energy modulation into a THz bunchtrain



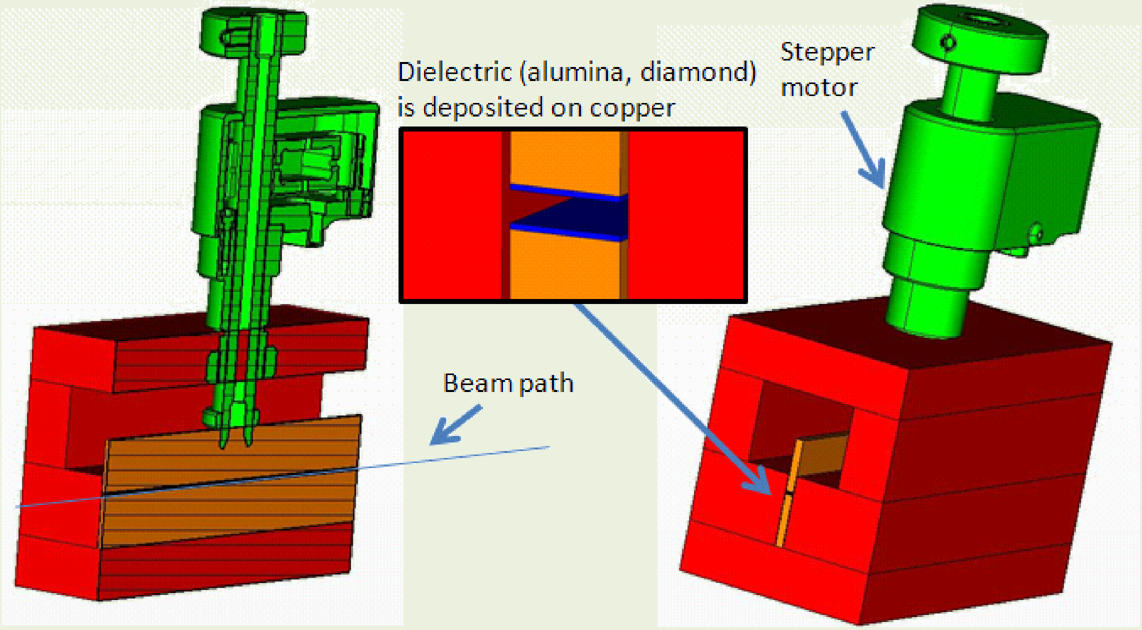
1. HIGH TRANSFORMER RATIO

High Transformer Ratio

- Wake mapping at higher frequency > 1 λ covered, **if you can pass the beam through**. Rule of thumb: aperture ≥ $6 \cdot \sigma_r$
- TR = lower gradient for witness beam → long structure;
- Structure-to-beam alignment is the name of the game; virtually 100% transmission is required
- 5D positioning stage, similar to what UCLA/SLAC designed for Kraken chamber at FACET.
  - Can be used for many other experiments
  - Can carry different structures simultaneously

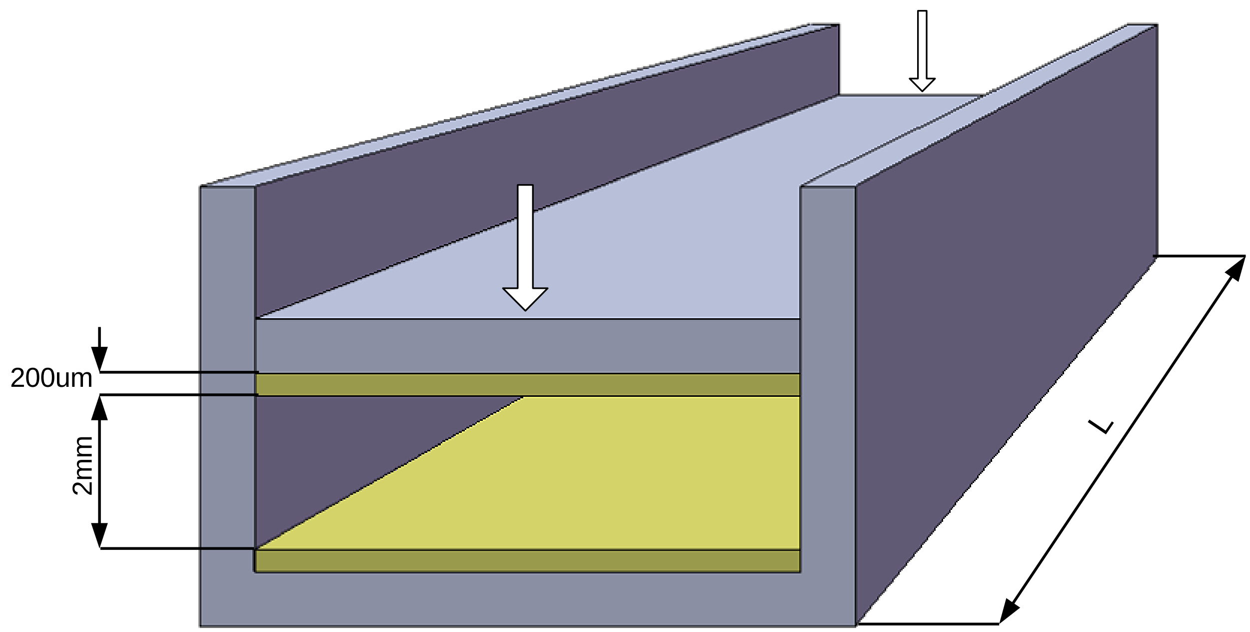


Kraken chamber “insides”
O. Williams, S. Barber (UCLA)
M. Dunning, D. McCormick (SLAC)



2. TUNABLE ENERGY CHIRP COMPENSATION

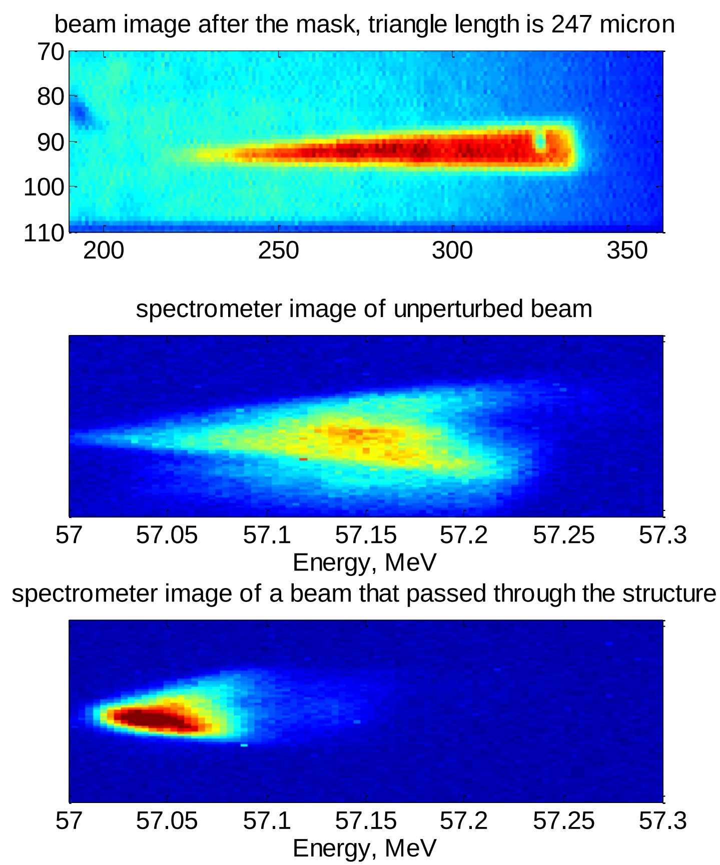
Plans: tunable E-chirp compensation

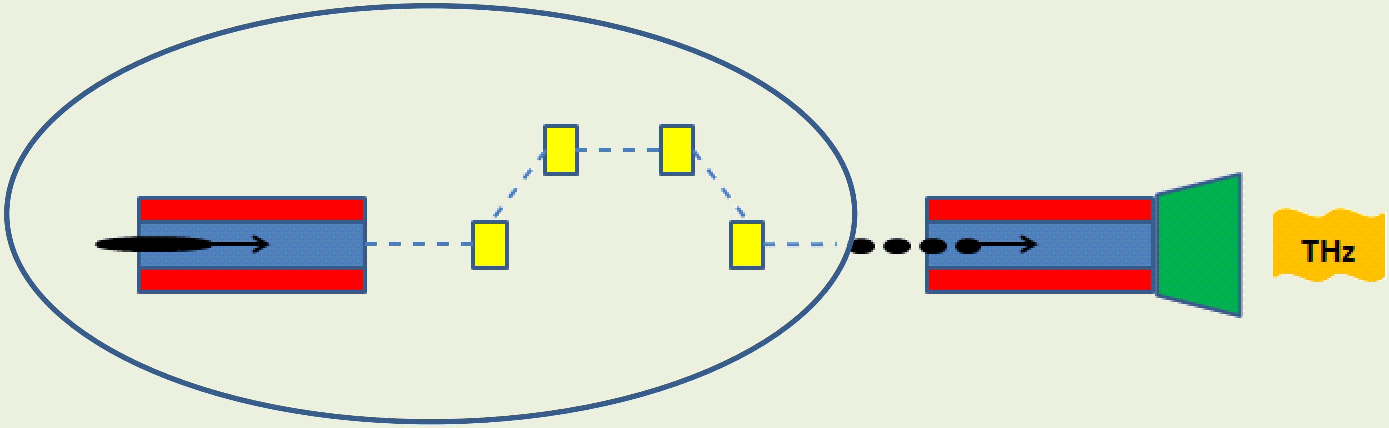


- Structure – to – beam alignment
- Changing chirp – adjusting structure for chirp compensation
- Spectrometer resolution: adding slits and performing slice – scan
- It can be a part of other experiment (energy modulation – bunchtrain conversion)

Proposed Experiment: Tunable Energy Compensation

- Adjustable geometry WF structure
- Tunable energy compensation is required in a real device
- Experiment is similar to the previous E - chirp compensation measurement
- Change beam E-chirp → adjust chirp compensation system
- Spectrometer resolution





3. ENERGY MODULATION CONVERSION TO A BUNCHTRAIN FOR THZ SOURCE

Table top beam-based THz source

BNL, ATF: S. Antipov, C. Jing et. al.
Phys. Rev. Lett. 108, 144801 (2012)

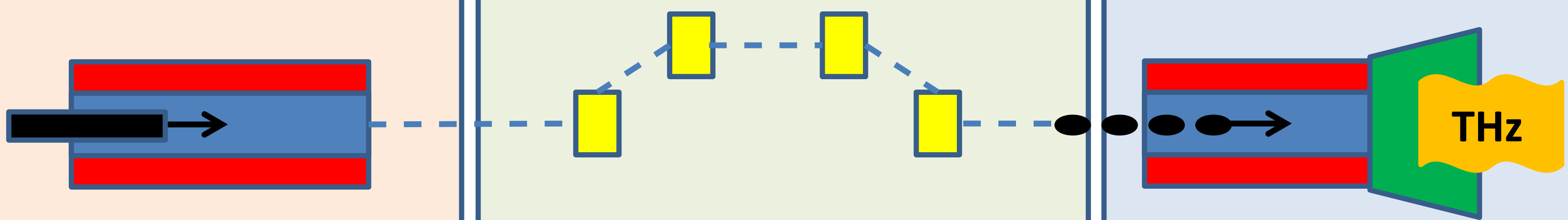
SLAC, NLCTA: D. Xiang et. al.
Phys. Rev. Lett. 108, 024802 (2012)

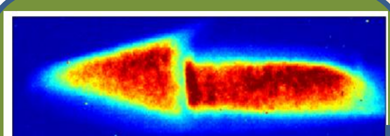
BNL, ATF: G. Andonian et. al.
Appl. Phys. Lett. 98, 202901 (2011)

Energy modulation via self-wakefield

Chicane energy modulation conversion to bunch train

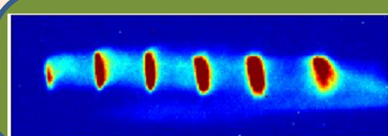
THz radiation wakefield structure





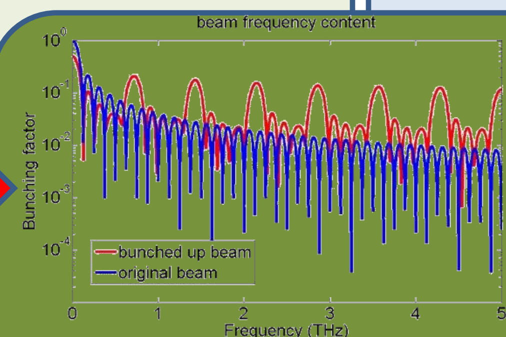
Measured beam spectrum

Energy chirped rectangular beam



Measured beam spectrum

Energy modulated rectangular beam

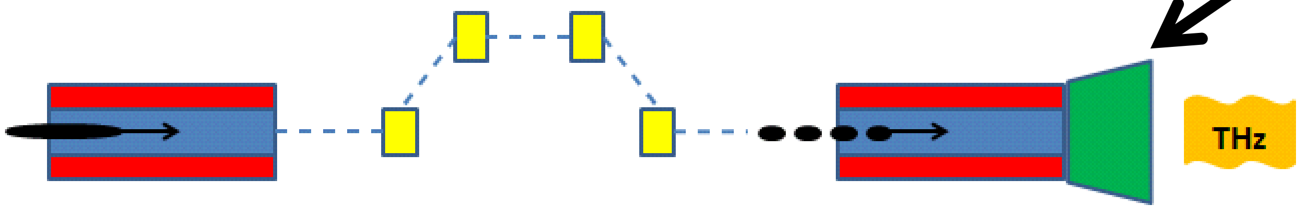


Bunch train frequency content

Tunable 10% source:
Range: 0.3-1.5 THz
Pulse bandwidth: 1%
Energy in pulse: ~ mJ

Flexible: each step has a tuning range

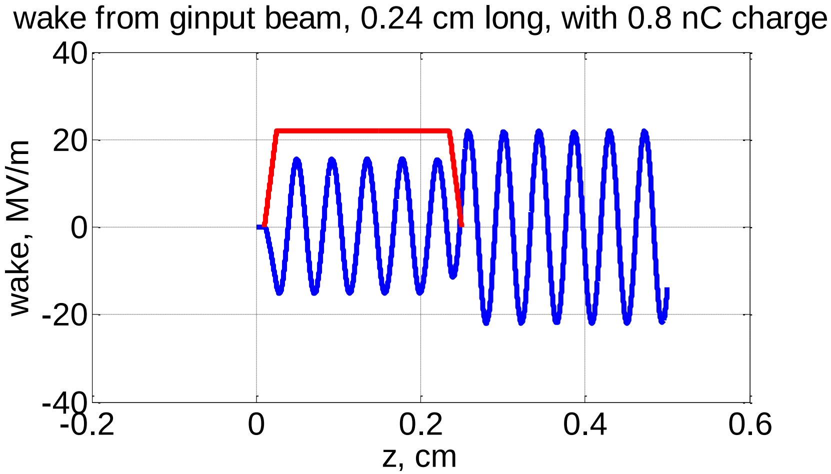
Couple Scenarios

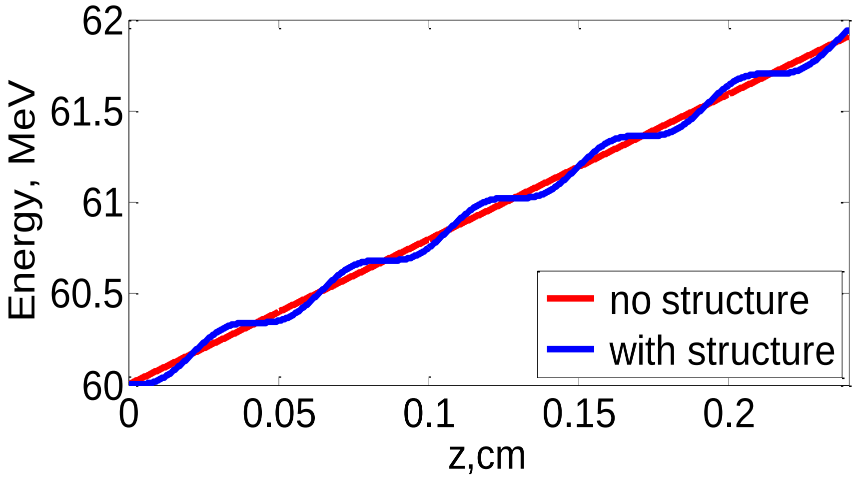


DWA structure	Beam @ the entrance	THz Radiation @ the exit
0.3mm / 0.4mm Quartz 3cm long	(ATF beam) 2.4mm, 0.8nC rectangular	6 MW peak, 0.7THz, 161ps pulse, 0.9%BW, 1.4mJ per pulse
1mm / 1.2mm Quartz 10cm long	(AWA beam) 6.3mm, 10nC rectangular	0.5 GW peak, 0.3THz, 320ps pulse, 1%BW, 155mJ per pulse

ATF example. Stage I: self-wake

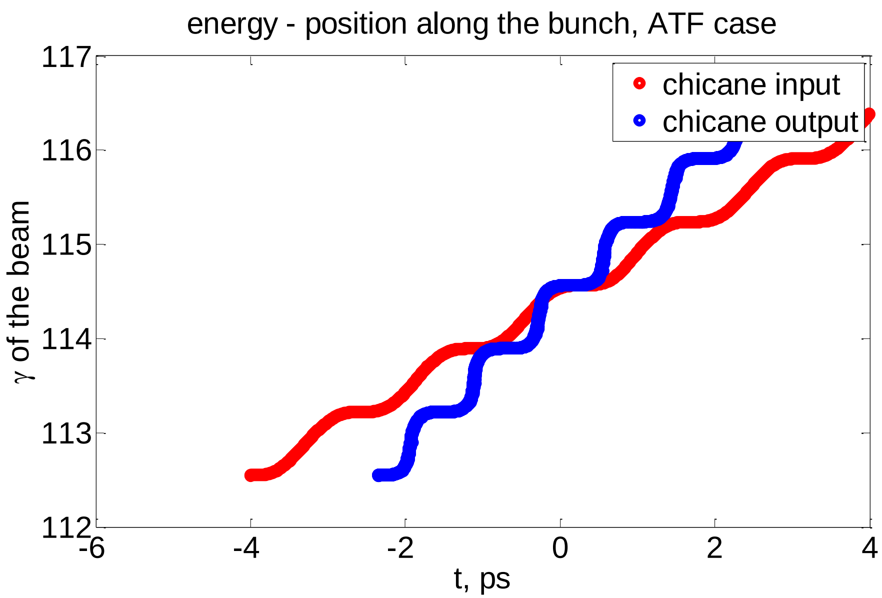
ID = 300um; OD = 400um; Quartz → 0.7 THz, v_{gr} = 0.395c, r_{sh}/Q = 210kOhm/m

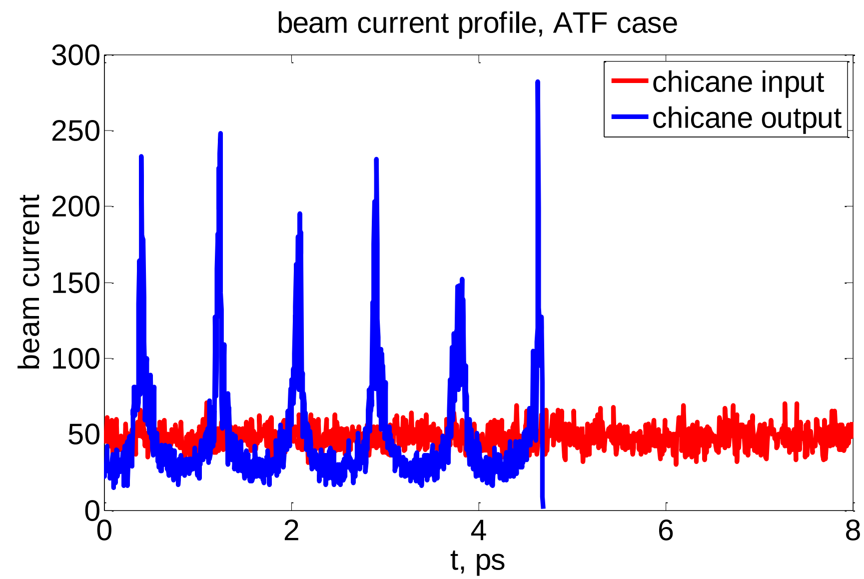


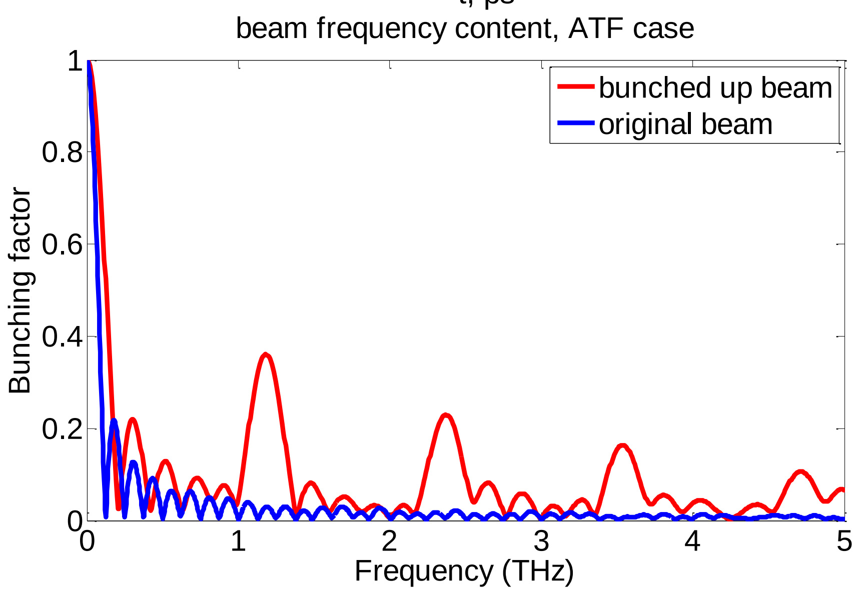


800 pC, 2.4 mm long flattop rectangular 2MeV energy chirp → ≤ 1 cm structure is required

ATF example, stage II: chicane

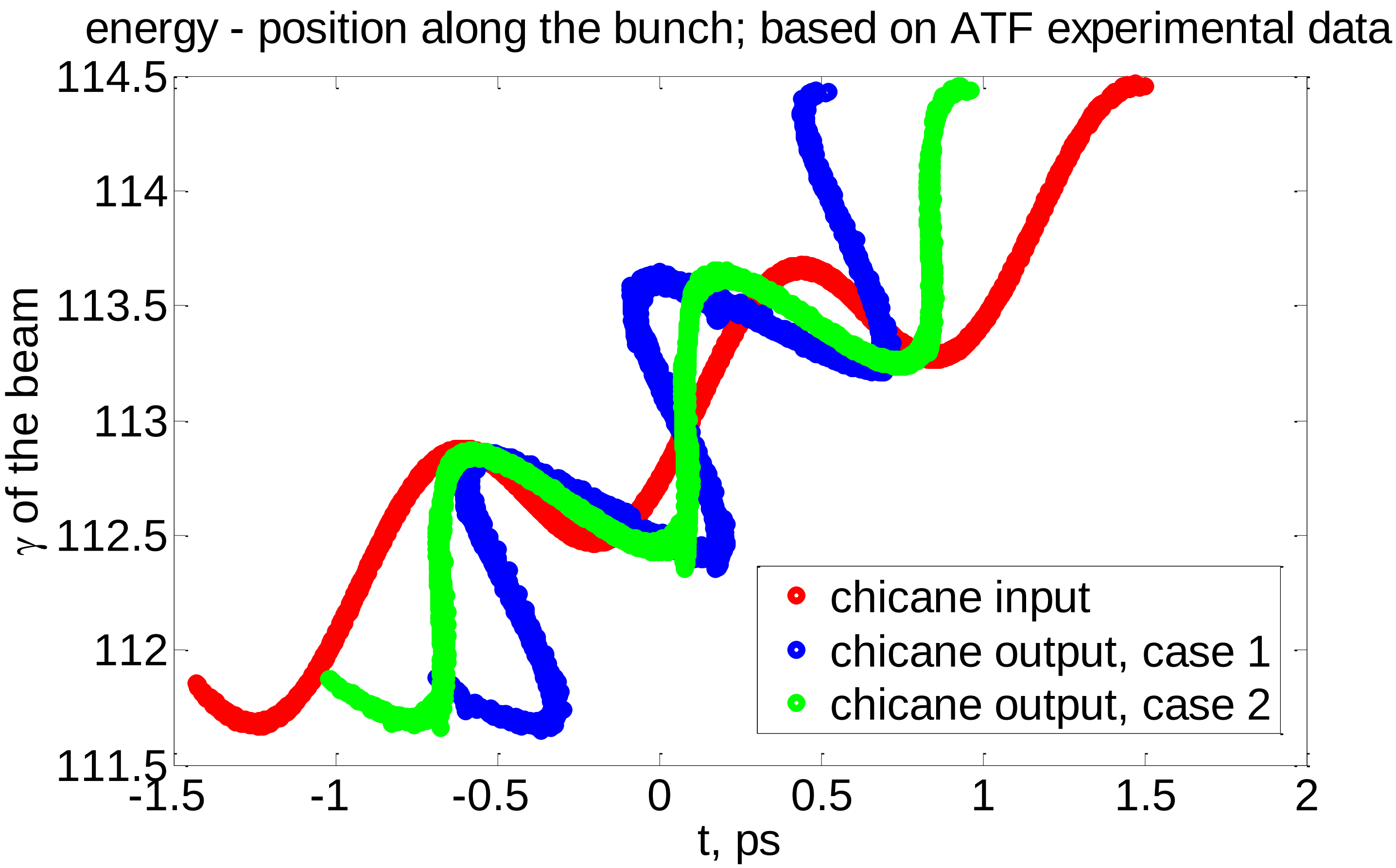






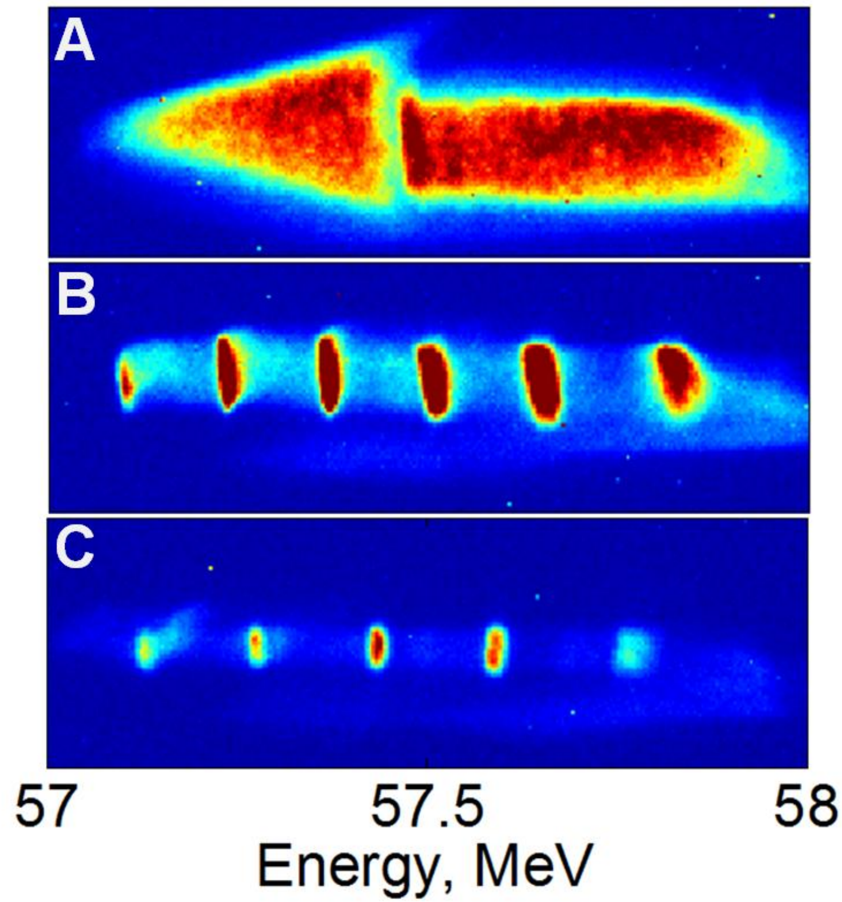
- R56 = 0.03m
- Particles between the bands are bunched!
- **<u>Bunched frequency content is higher then the self-wake bunching frequency</u>** (can be almost 2 times higher)
- Tunability

Adjustment by chicane



Proposed Experiment: Bunching with Chicane

- Demonstrate Stage I + Stage II; Energy modulation followed by the chicane
- We are designing a chicane to fit after the "IP" chamber (R_{56}~=0.03m; 0.5m long design with PM); spectrometer will have to move a little bit
- Use CTR interferometry to measure bunching
- Observe tunability by a) adjusting the chicane, b) using tunable wakefield structure



Summary

1. Enhanced Transformer Ratio demonstration
2. Tunable beam energy chirp compensator
3. Conversion of self-wake energy modulation into a THz bunchtrain

- designed on previous experience
- inter-related, share hardware, structures
- part of a big picture:
  - FEL applications
  - table top high power, narrow band, tunable THz source
- Hardware
  - Positioning stage
  - Spectrometer resolution
  - Chicane