Flat-beam-driven dielectric-wakefield acceleration in Slab structures*

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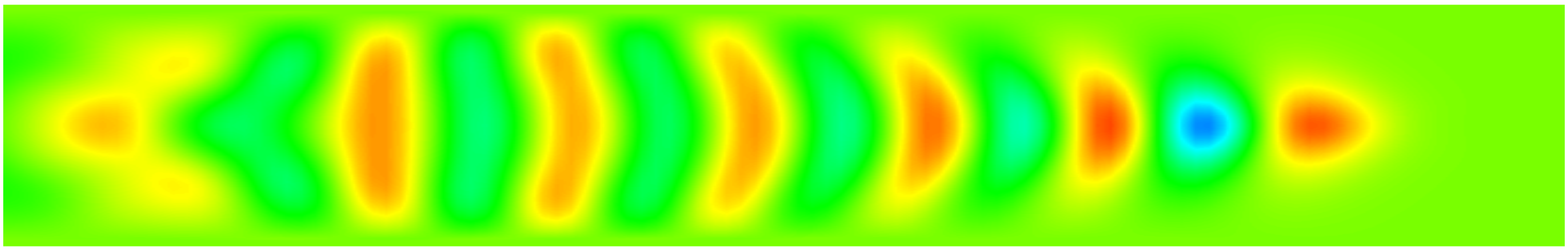

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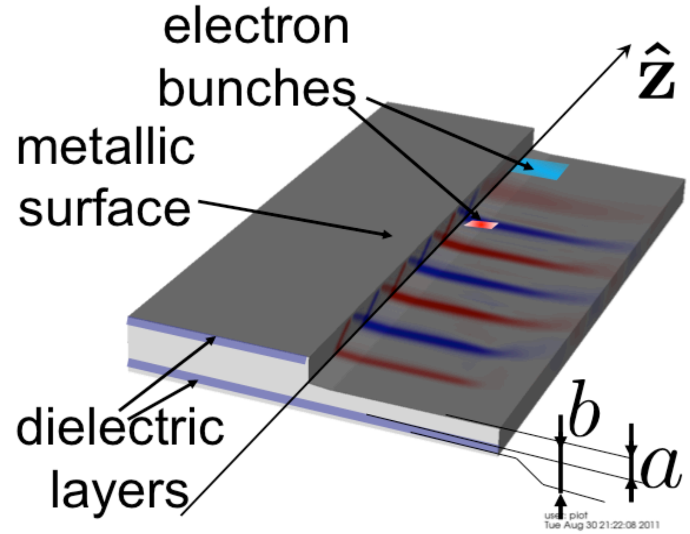
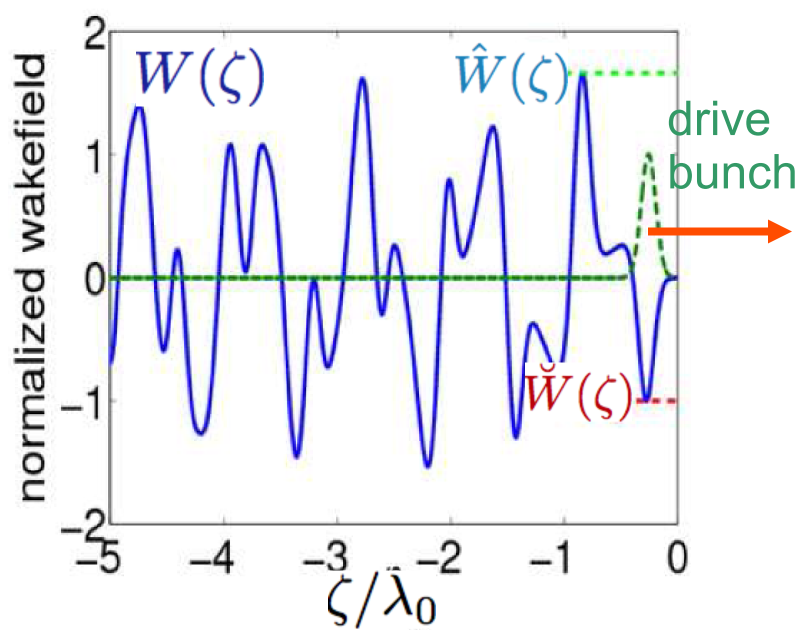
Motivations

- Demonstrate high-gradient (> 100 MV/m) acceleration in slab dielectric-lined wave-guides (DLW)
- Makes use of ASTA phase-space manipulation methods to advanced acceleration,
  - flat beams needed,
  - shaped current profile for enhanced transformer ratio

$$\mathcal{R} \equiv \frac{\hat{W}(\zeta)}{\breve{W}(\zeta)}$$

- high-rep-rate of ASTA also enable multibunch operation of DLW.

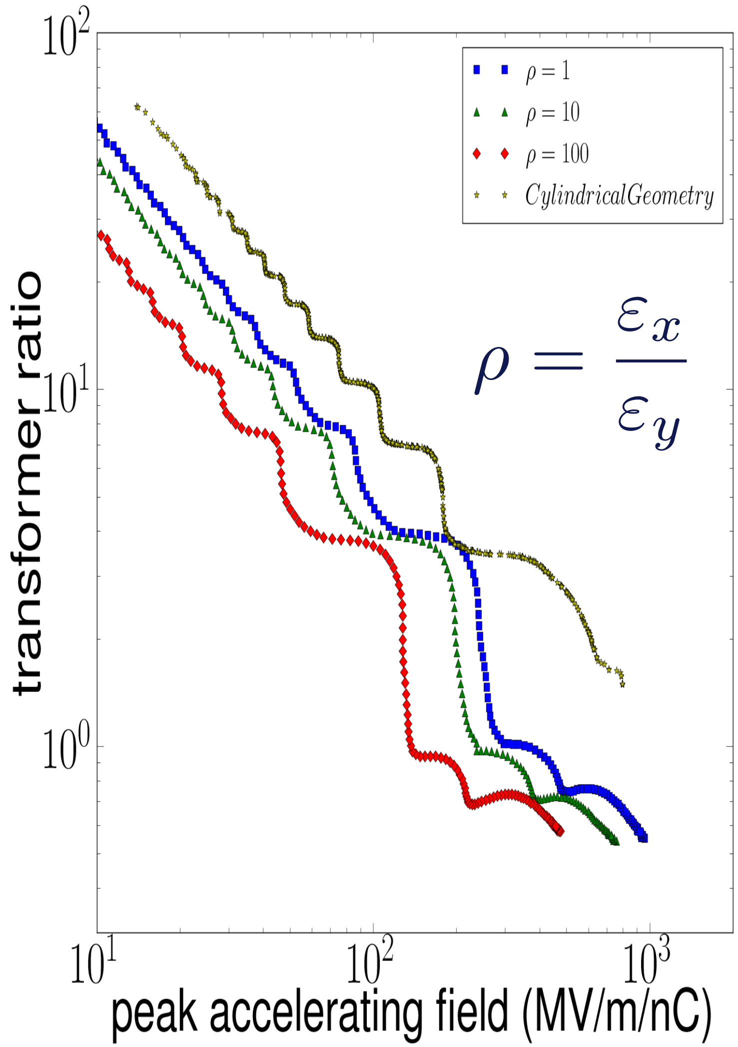




A. Tremaine PRE (1997), C. Jing PRE (2003), D. Mihalcea PRSTAB (2012)

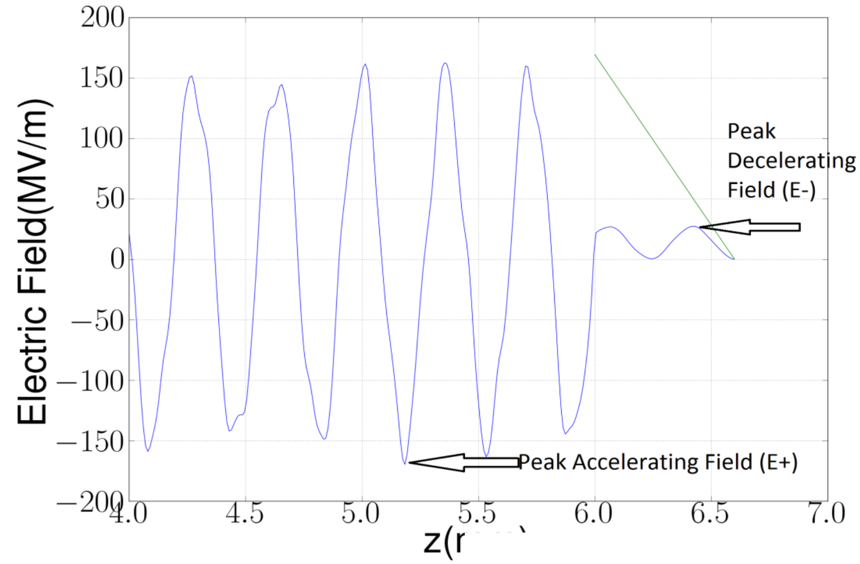
Flat beams

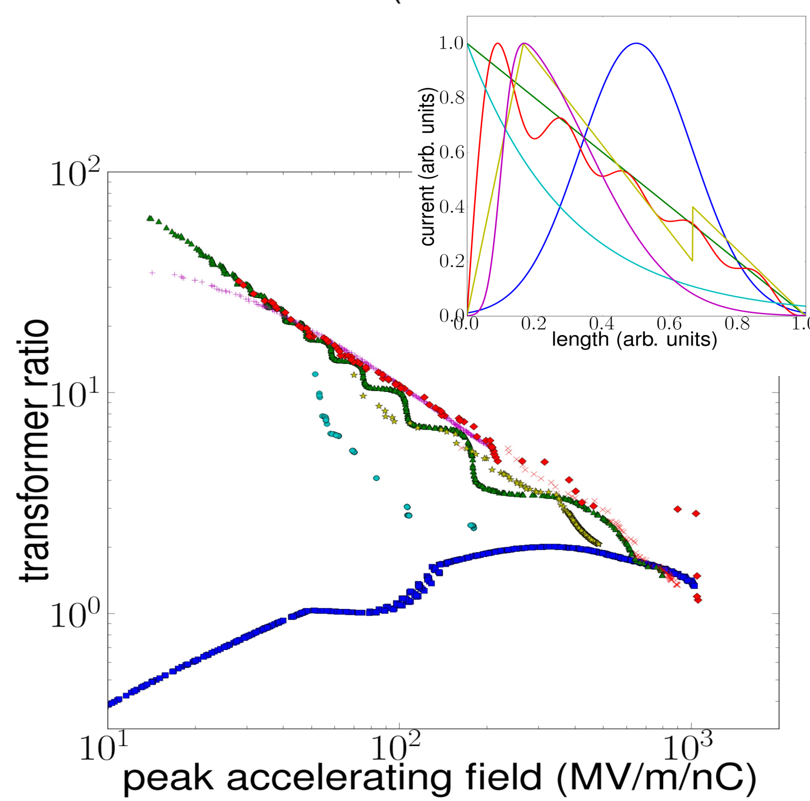
- Slab structure recently tested with round beam [Antipov (2012), Andonian (2012)]
- The use of flat beam could enable the production of higher-charge lower-emittance (in one plane) drive bunches
  - smaller gaps (➔higher acc. fields)
  - or lower energy bunch
- The use of flat beam with slab sacrifice fields compare to cylindrical structures



Current shaping

- maximize TR ➔ need asymmetric current profiles
- minimize energy spread of drive bunch ➔ more sophisticated shape
  [Bane (1985), Jiang (2012)]
- asymmetric current profiles readily available at ASTA (due to nonlinearities in phase space)
- more precise control will require the EEX beamline

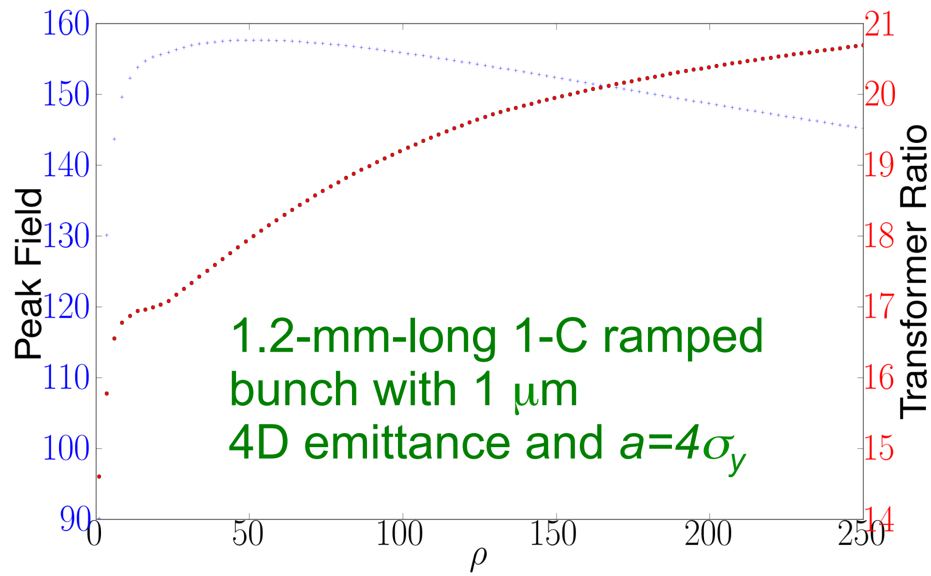


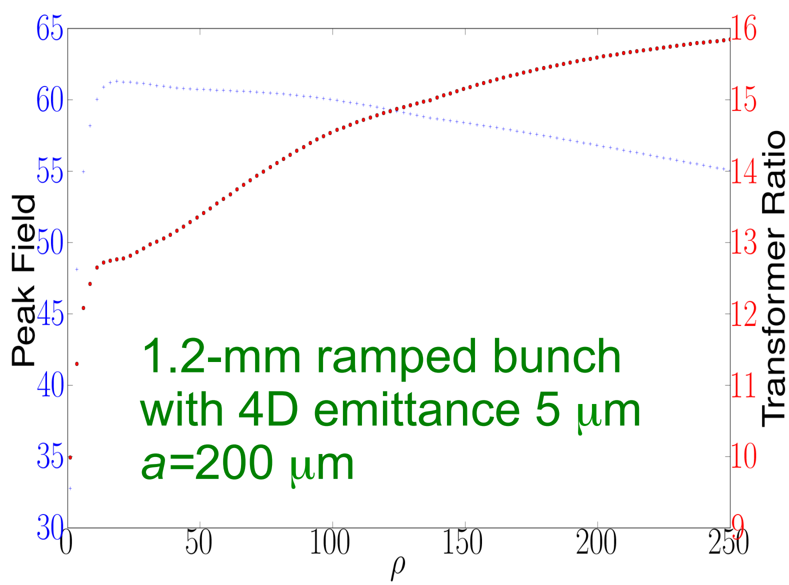


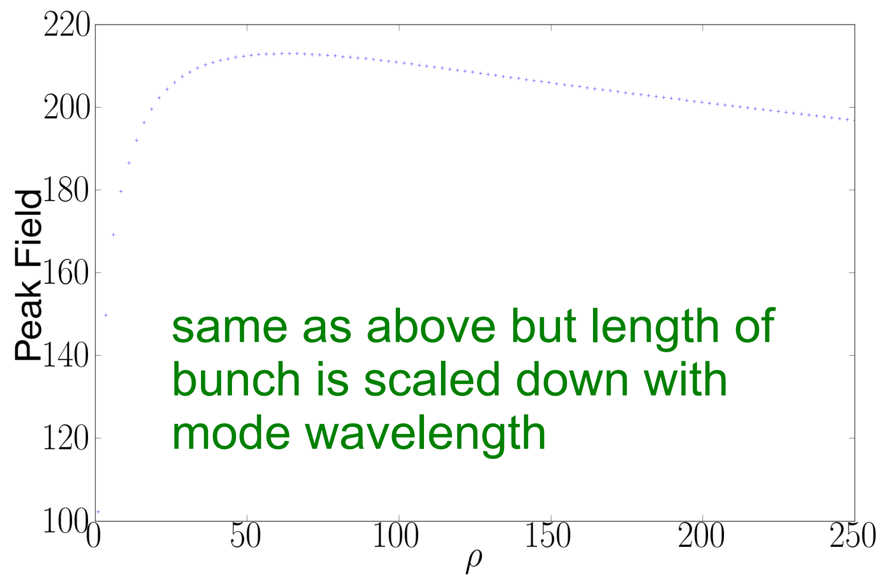
F. Lemery, IPAC11, IPAC12

Flat beams in Slabs

- flat have lower charge density so that E-field depends on the flatness

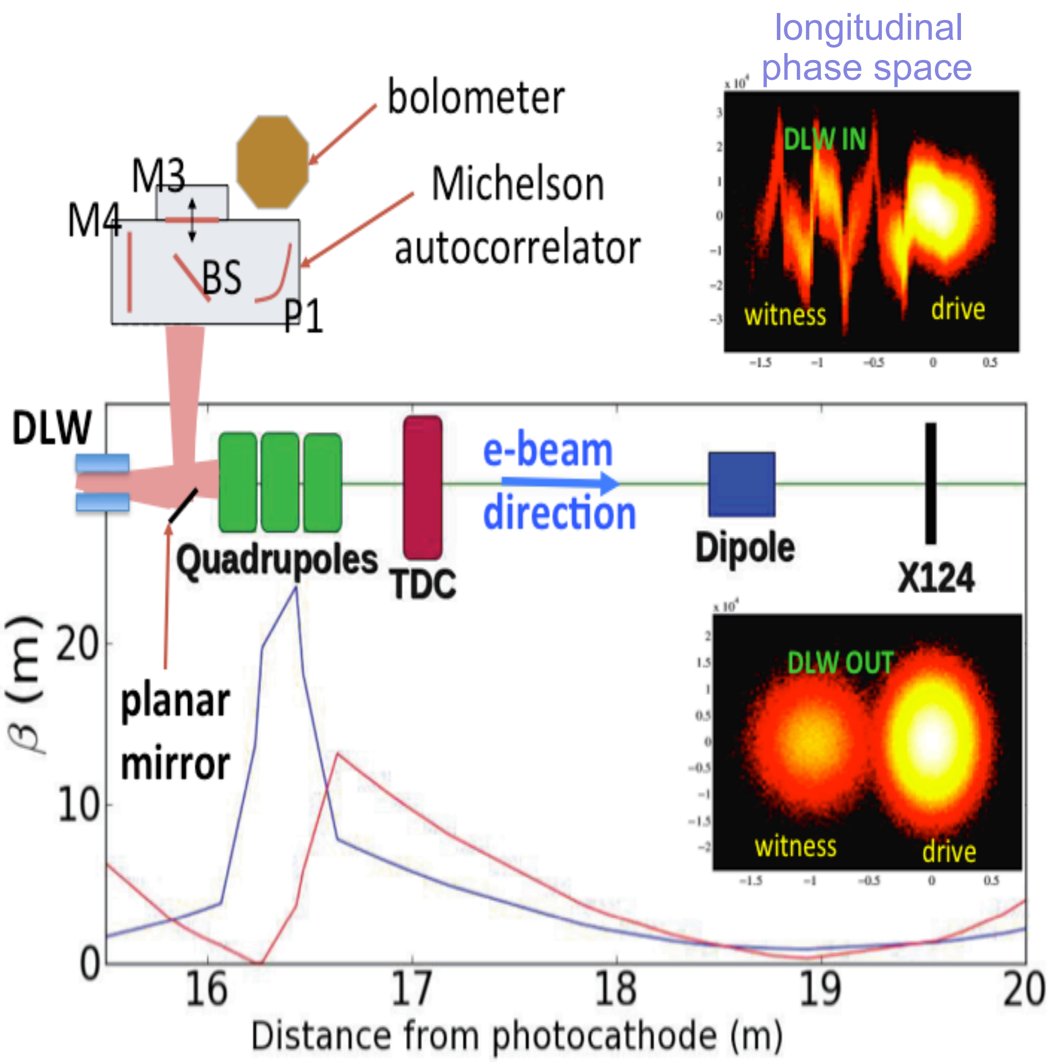






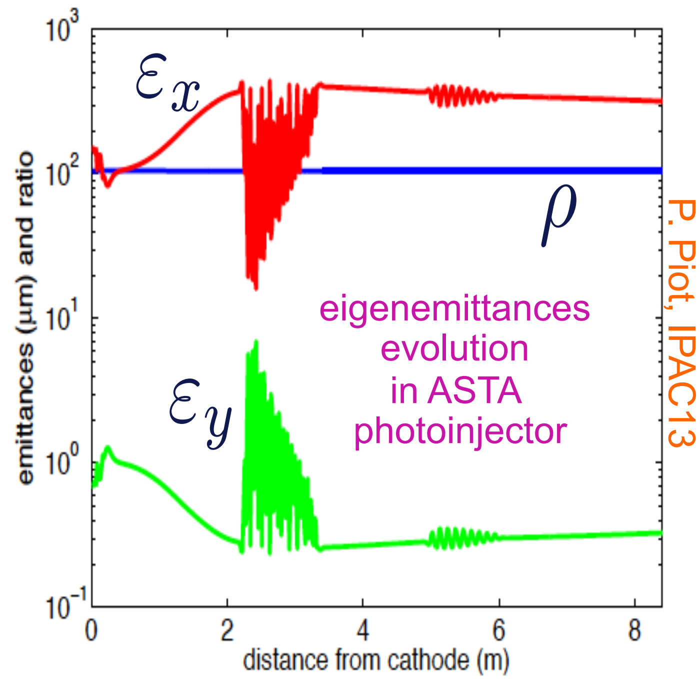
Experimental setup

- focus beam in DLW,
- detect THz radiation outcoupled from DLW (➔modes information),
- downstream energy spectrometer,
- generic setup:
  - can be located in 50-MeV or high-energy area (~300 MeV),
  - can be used for other beam-driven acceleration tests



Experimental Plans

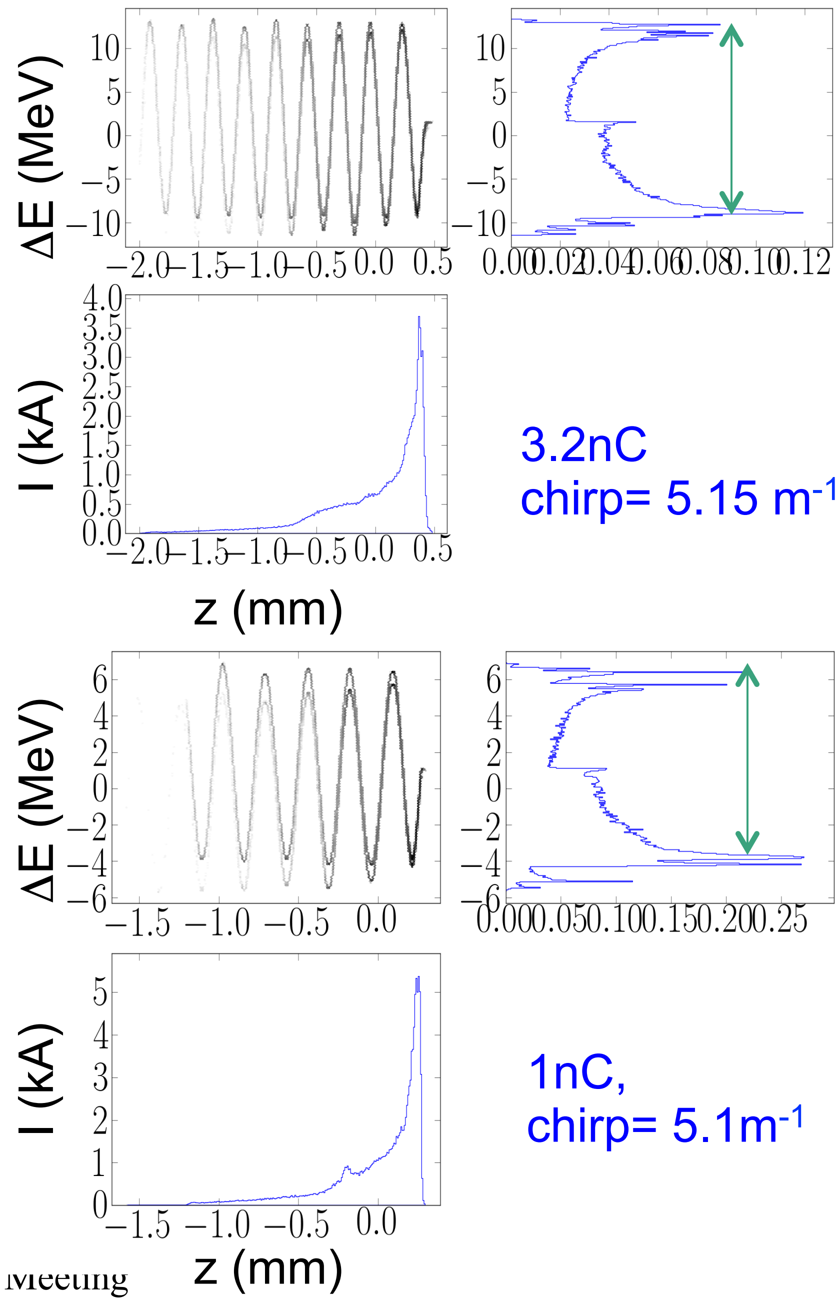
- **Run I**: compressed flat-beam generation and characterization,
  - emittance, spot size at potential DLW location(s),
  - parametric studies vs bunch charge
- **Run II**: wakefield generations and beam-wake interaction
- **Run III**: enhanced transformer ratio with EEX and/or with alter-native pulse shaping scheme (on-going studies)



parameter	flat-beam configuration	round-beam configuration	units
Q	3.2	3.2	nC
E	47.18	48.77	MeV
ε_x	105.04	5.43	μm
ε_y	0.31	5.44	μm
ε_{4D}	5.53	5.44	μm
ρ	$\simeq 334$	$\simeq 1$	–

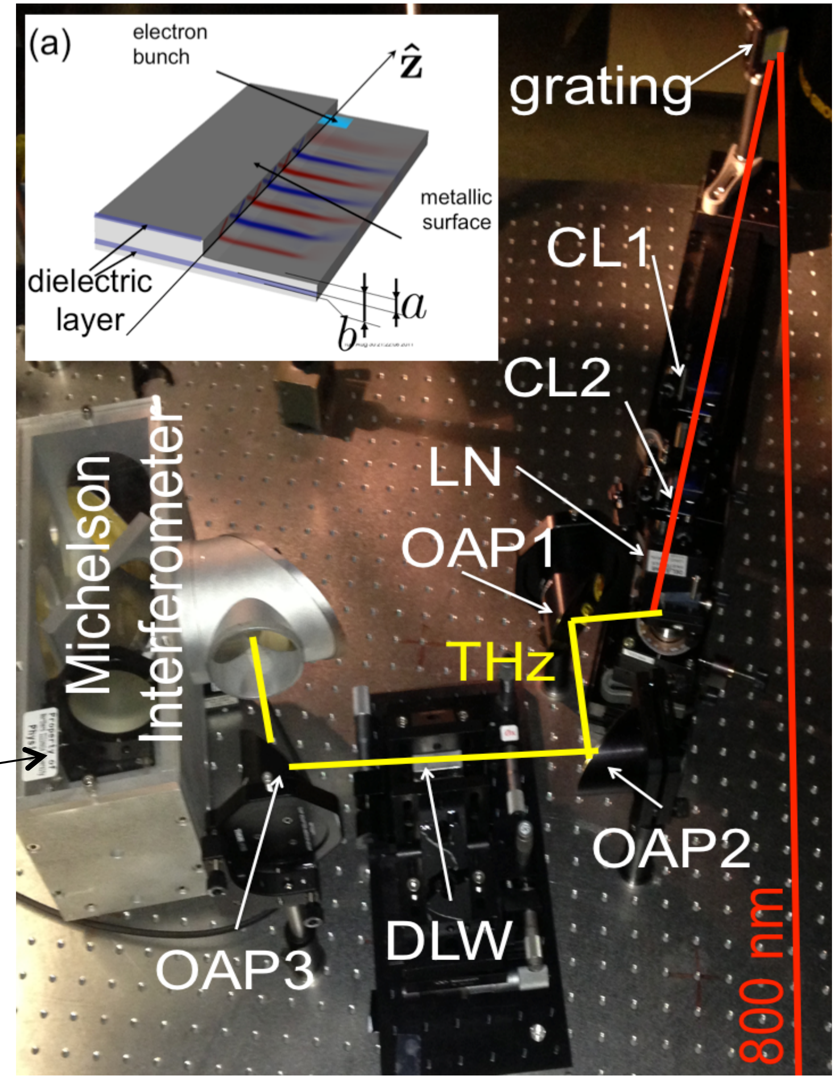
Run II: expected outcome (40 MeV)

- start-to-end simulations (IMPACT-T/Z, VORPAL or Green's function code)
- use nominal ASTA injector setup with a 2-cm DLW
- long tail after compression can sample wake ➔ strong energy modulation
- peak current (and wake) tunable with charge and compression factor.



Status

- Most of the experimental hardware in hands:
  - one stucture procured from Euclid lab,
  - attocube® positioner (UHV compatible test at FLASH to be ordered soon)
  - THz interferometer
- One structure is being characterized with a THz-pulse setup from the A0 laser lab.



- detailed beam optics + further simulations needed will depend on exact location of experiment.