



Beam-driven wakefield acceleration with enhanced transformer ratio

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Motivations

- Ultimate Goals:

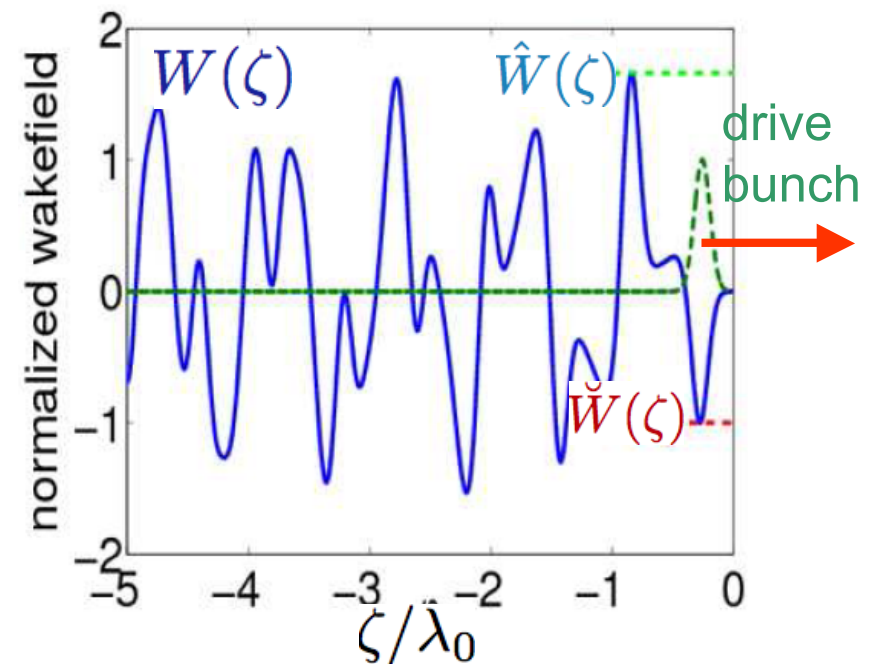
- Observe acceleration with enhanced transformer ratio,
- Measure GV/m accelerating fields.

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

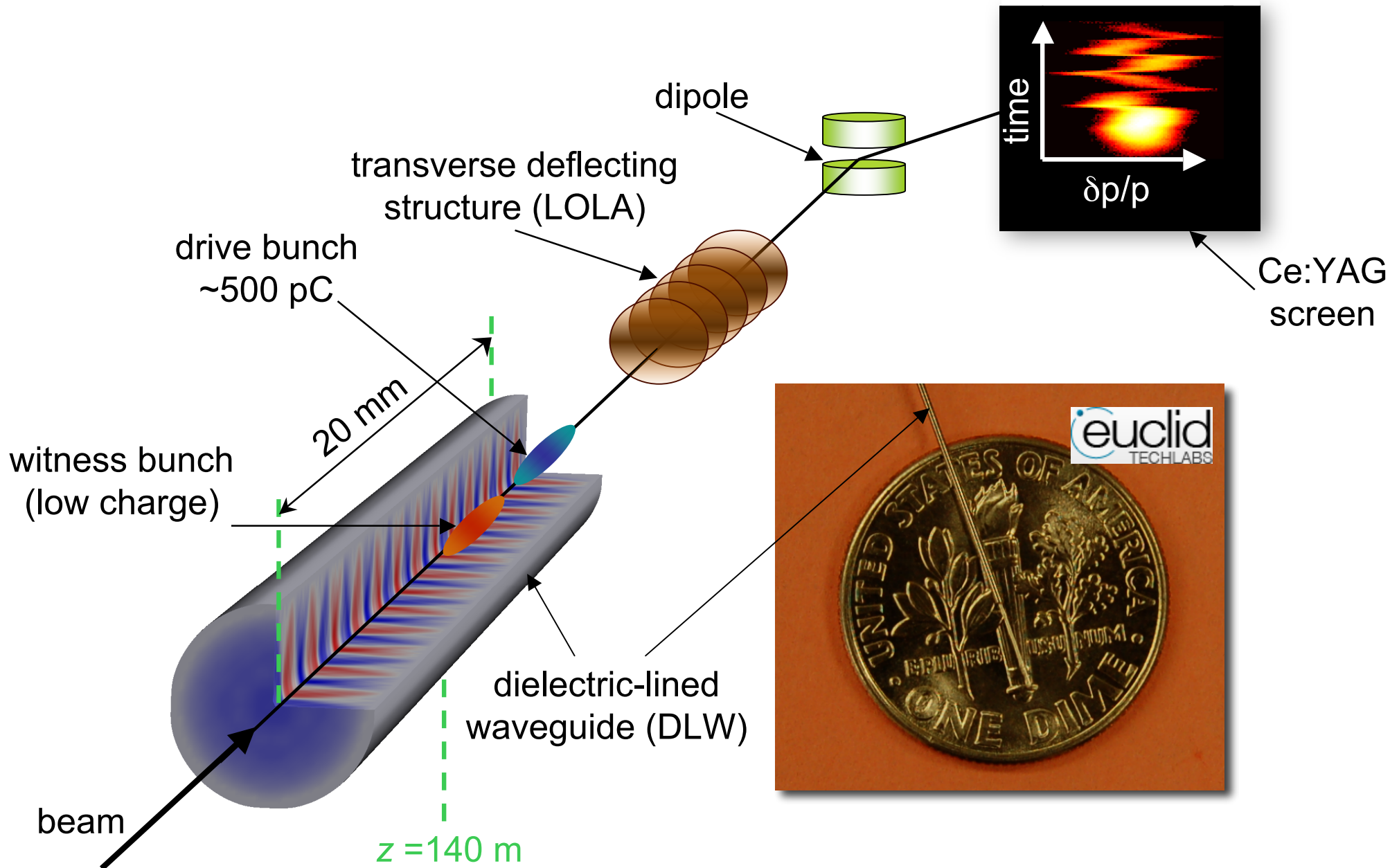
- Ingredients/Challenges:

- Dielectric structure,
- Location, beam focusing,
- Ramped-current bunches,
- Generation of witness bunch,
- Diagnostics.

- We consider dielectric-lined waveguides (simple, cheap, high-E breakdown).



Proposed experimental set-up



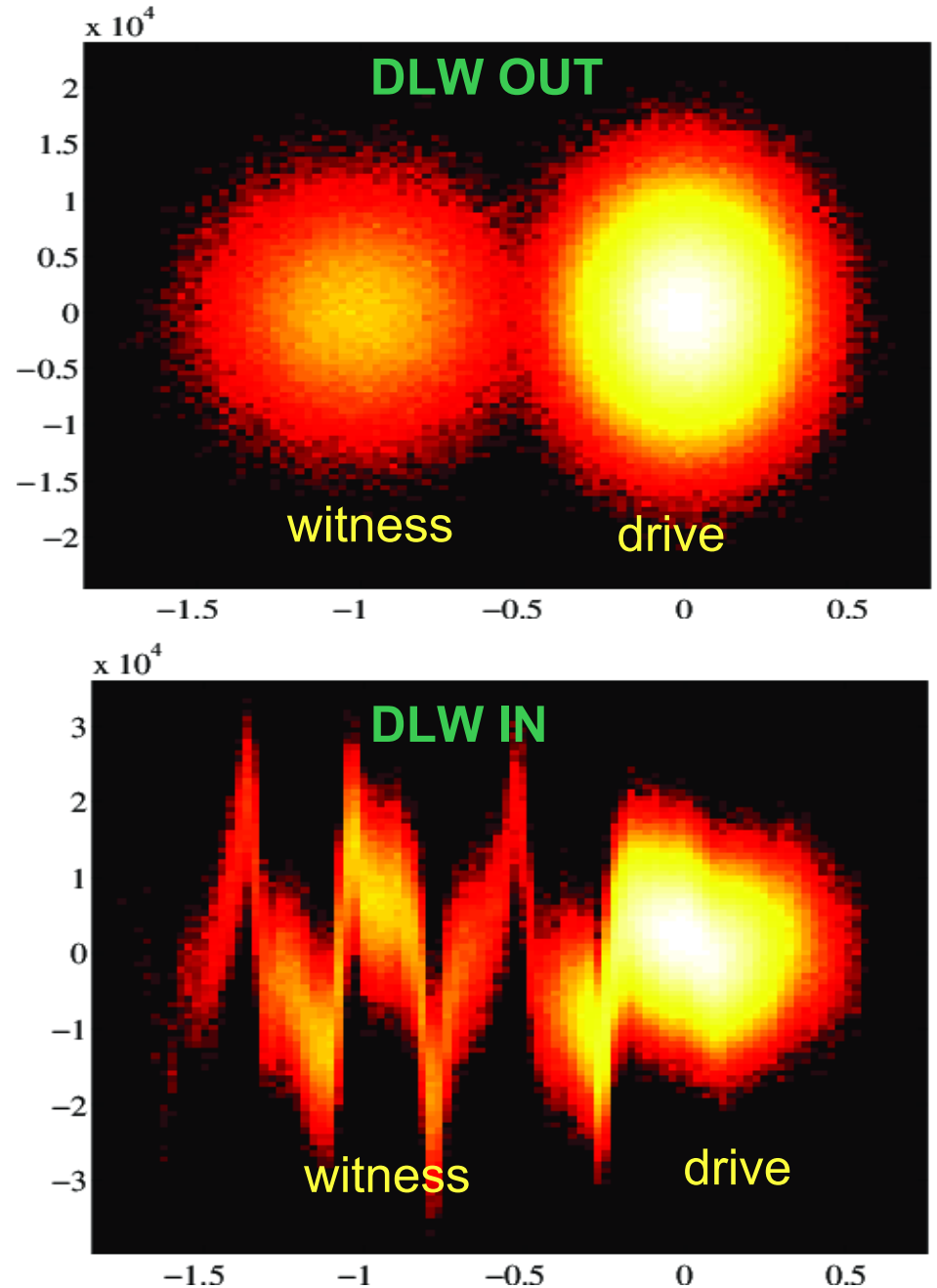
Dielectric-Line Waveguide (DLW)

- DLW parameters driven by:
 - FLASH beam parameters
 - Desired peak fields and trans. ratios,
 - Collimator energy acceptance (FW~4%)
- EuclideLabs LLC to provide/prepare structures (incl. cut, metallization, holder design/fabrication)



Proposed experimental method

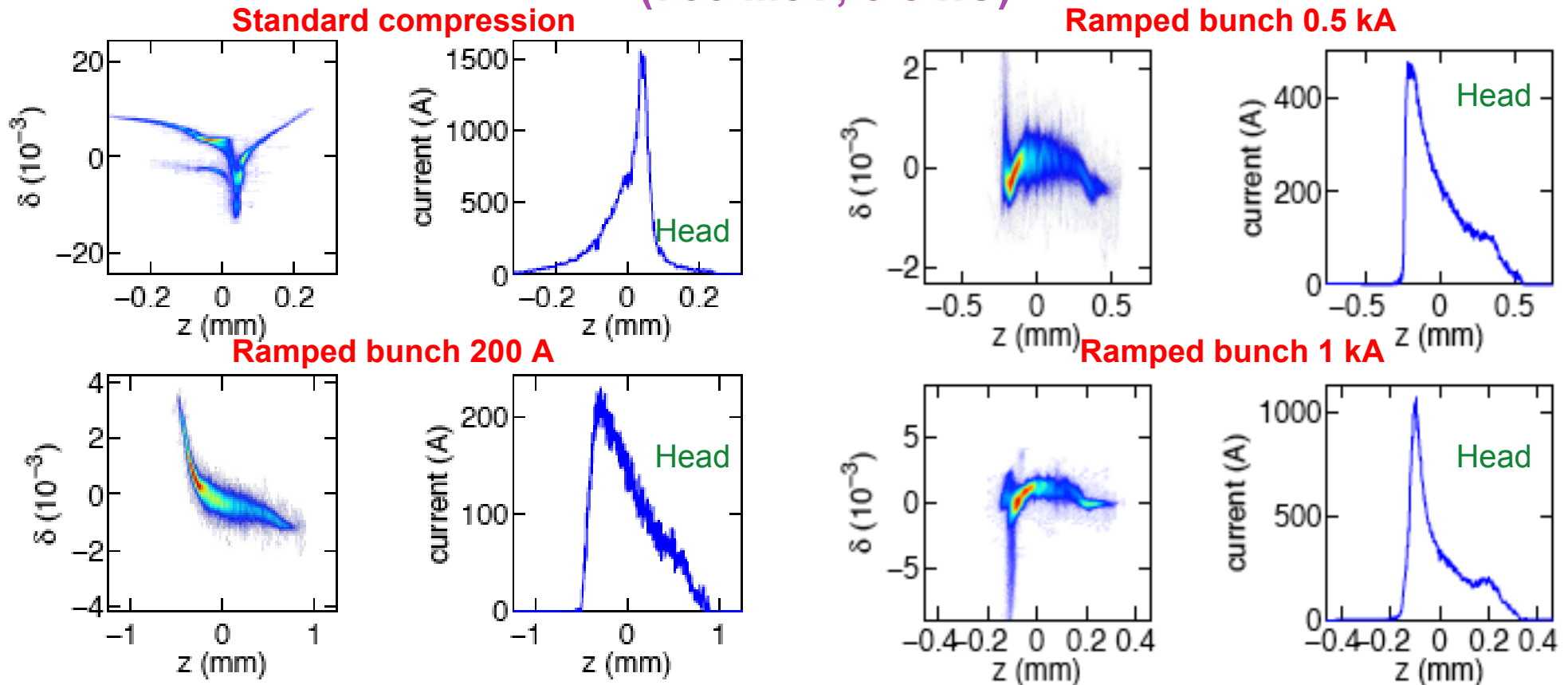
- Longitudinal-phase space w/wo beam going through DLW,
- Energy-averaging over time slice provides the wakefield,
- Direct measurement of transformer ratio.



Generation of ramped-current bunches ✓

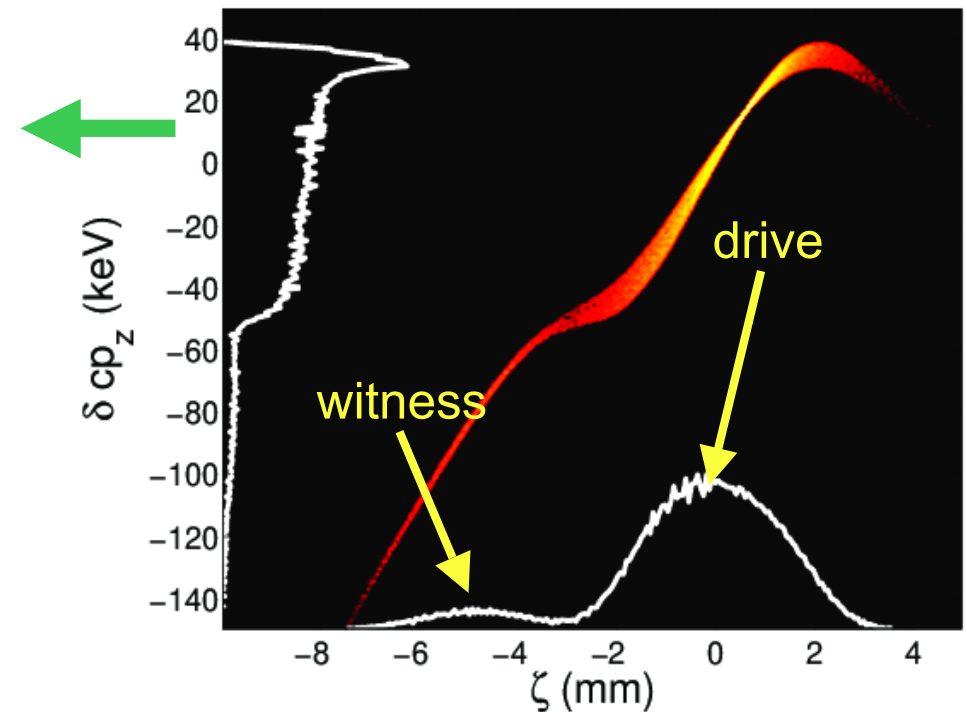
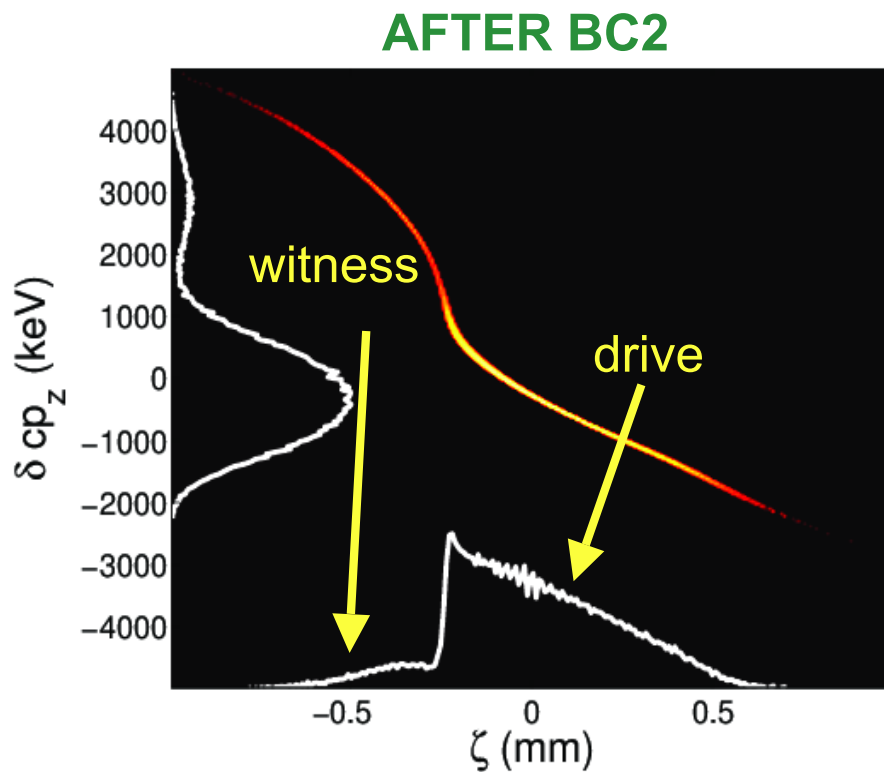
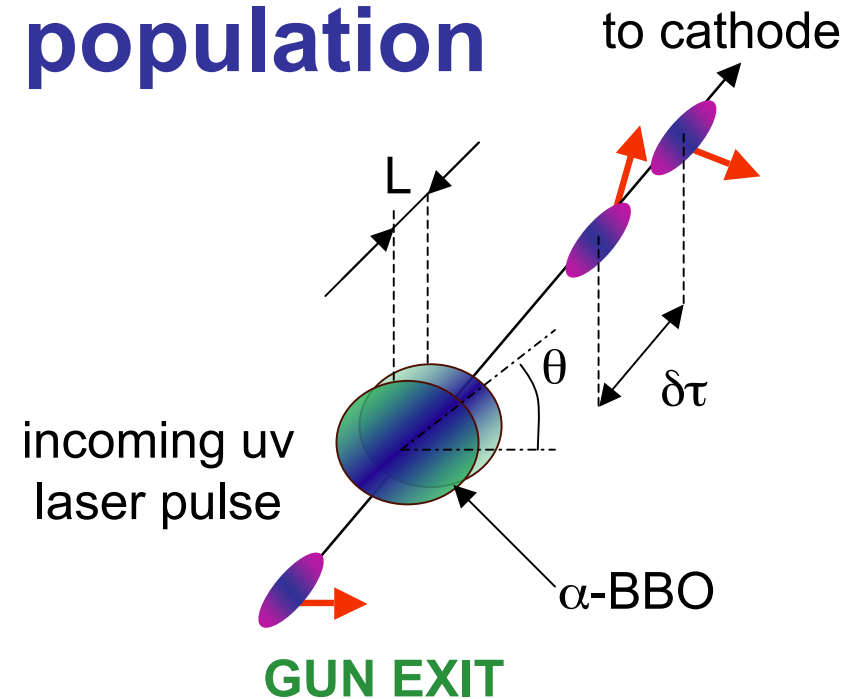
- Current shaping done by impressing nonlinear correlation in the longitudinal phase space [<http://arxiv.org/abs/1109.1413>]
- Demonstrated at FLASH in Jan 2011.

(700 MeV, 0.5 nC)



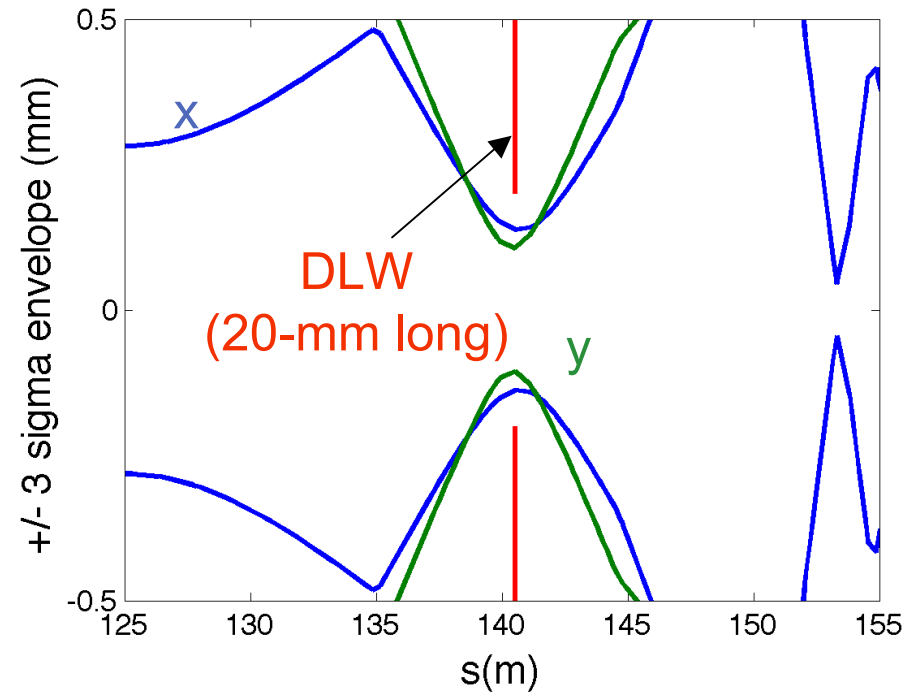
Generation of a witness population

- Witness bunch produced with a birefringent crystal
- Drive/witness hierarchy preserve downstream of BC2
- Preliminary experiments planned at HBESL (FNAL)



Focusing in the structure

- Possible to tune quads in ACC5-ACC7 to get smaller β 's at 140 m.
- $\sigma < 50 \mu\text{m}$ for $3 \mu\text{m}$ emittance and target $\beta = 1 \text{ m}$ (smaller/asymmetric β also possible).
- **Issue not yet addressed:**
differential focusing for drive and witness bunches and possible compensation schemes...



Requests for CY2012 (for discussion)

- Install structure at $z=140$ m (vacuum break)
- Shifts: Five 12-hours shifts
 - Shift1: transverse optics
 - Shift2: reproduce Jan 2011 data and commission double bunch
 - Shift3: align through DWL structure and measured wake for nominal compression
 - Shift4/5: data taking/optimization of transformer ratio
- Beam structure: single bunch, energy not important (700 to 1200 MeV OK)
- Notes:
 - structure/holder will be fabricated by end of CY2011 (?)
 - Several of our investigations seem redundant with other proposals, e.g. Krassilnikov (should try to combine)

Summary & plan of action

- A DLW based acceleration test at $z=140$ m appears to be feasible at FLASH I (concept passed all sanity checks so far),
- Experimental setup available at FLASH is **unique**:
 - First single-shot measurement of time resolve wake from THz DLW
 - Measurement of transformer ratio >2 (shooting for 4)
- Few things remain to be done especially S2E simulations of the experiments (will be done by end of CY2011),
- Beamtime in CY2012 would be highly desirable.