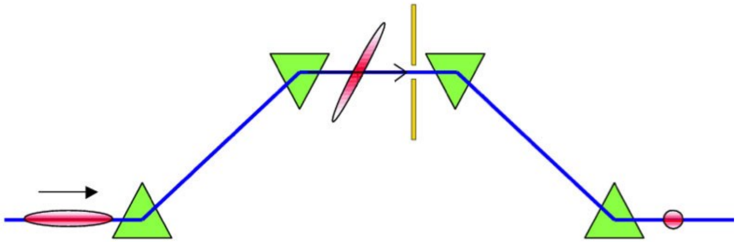
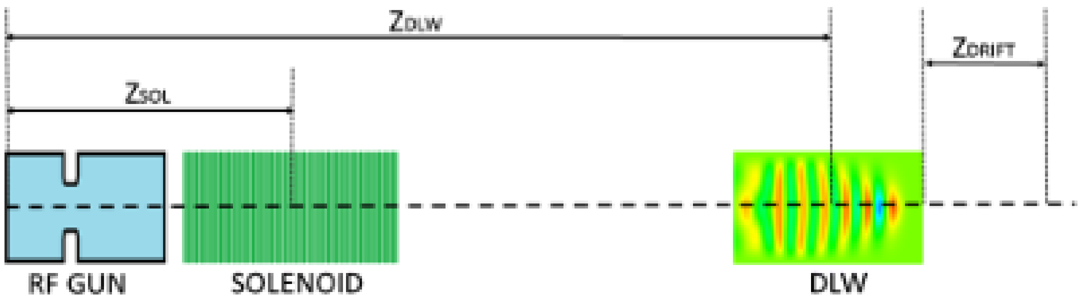
Ballistic Bunching @ PITZ

Goals, Progress and Looking Forward

Overview



- Modern accelerators and bunch compressors impart a chirp on an electron bunch by accelerating off-crest; the resulting chirp is converted into a density modulation via a bunch compressor with appropriate R_{56}.
- At low-energy (<10 MeV), energy differences still have relevant velocity differences $\gamma = \frac{1}{\sqrt{1-\beta^2}}$, $R_{56} = \frac{L}{\gamma^2}$
- Can we use dielectric-lined waveguides to impart a chirp which will transform into a density modulation in a subsequent drift?



Wakefields

- The DLW can sustain both TM-monopole (accelerating) and dipole-HE (deflection) modes.
- In principle HE modes are only excited from misalignments and would generally deflect the beam in the misalignment direction plane.
- The expected momentum change imparted on a line charge can be calculated via (where κ is the loss factor and k is the wave number of the mode)

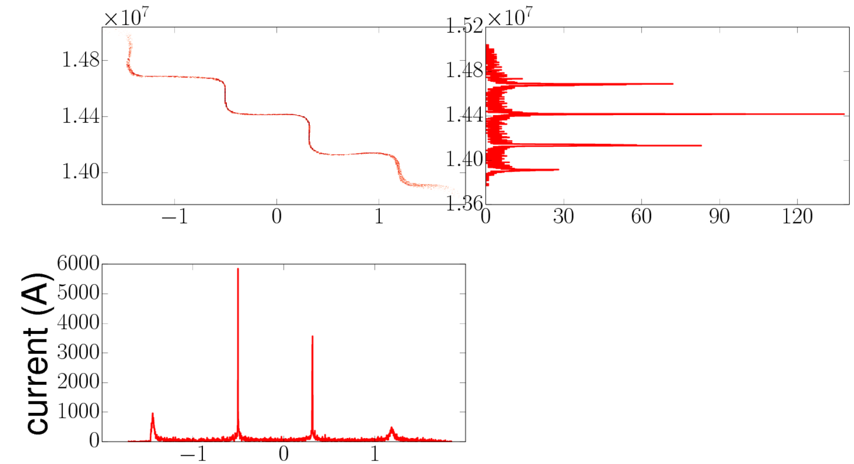
$$\Delta E(z) \simeq c\Delta p_z(z) = L_{dlw} \int_{-\infty}^{z} dz' \Lambda(z - z') w_z(z'), \qquad w_{z,m}(\zeta) = \kappa_m \cos(k_m \zeta),$$

Mode excitation

- The wakefield strength is proportional to the current of the bunch.
- While the structure may support a fundamental mode with frequency f_0, the bandwidth of the electron bunch must also excite it.
- This is especially relevant to the novel pulse stacking capability of PITZ for e.g. super-Gaussians.
- It is best to have a sharp head, the 2 ps rise time of the MBI laser suggests an excitation frequency of 250 GHz. Our coated structure has a fundamental frequency of 300 GHz, uncoated 200 GHz.

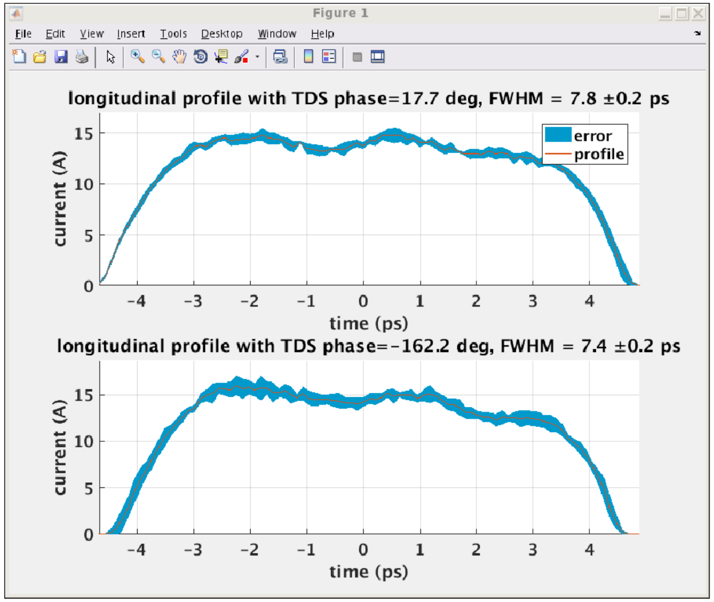
Optimizing Bunching

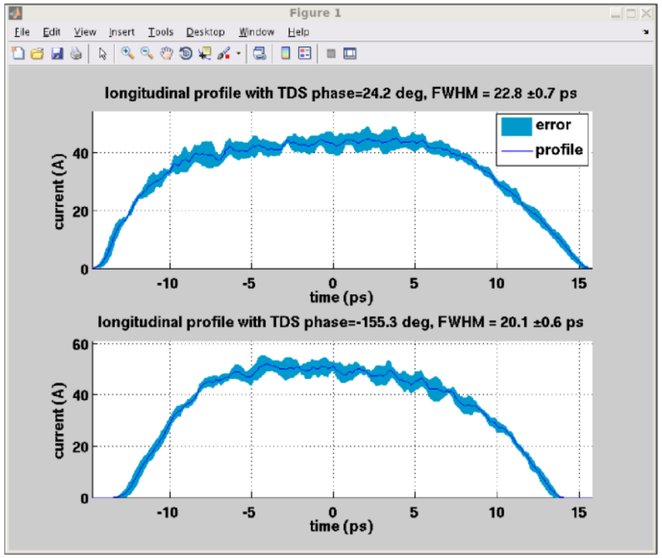
- The goal of our experiment is to generate and characterize the highest peak currents possible.
- IN addition, can we also accelerate in the booster off-crest to generate the correct chirp to generate the “staircase” distribution?



Progress-laser dev

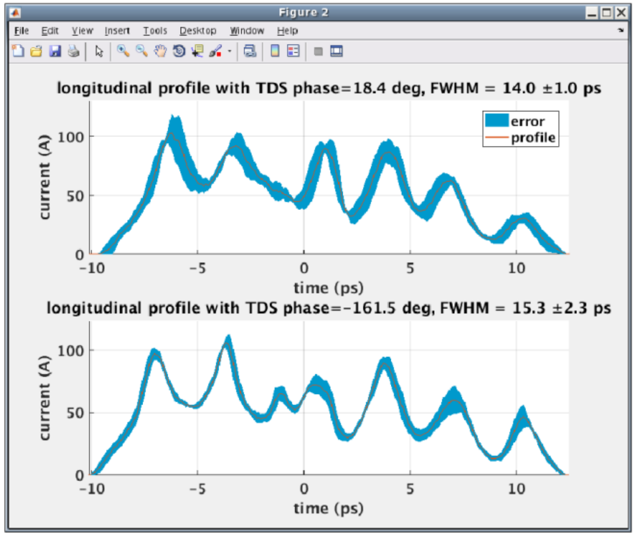
- Have generated flat-top super-Gaussian distributions for 8 and now 12 ps.
- The longer distributions (for same charge) allow significantly more charge to be transmitted through the structures.

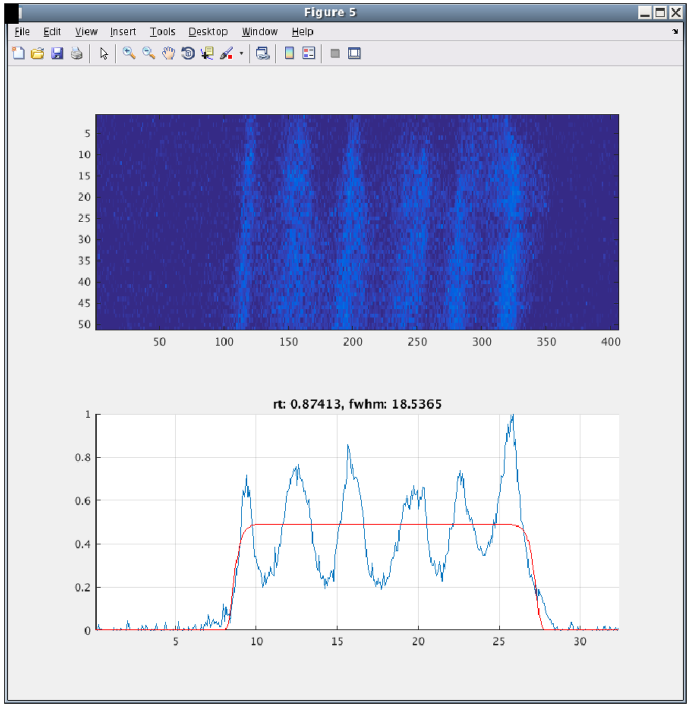




Progress – beam transmission

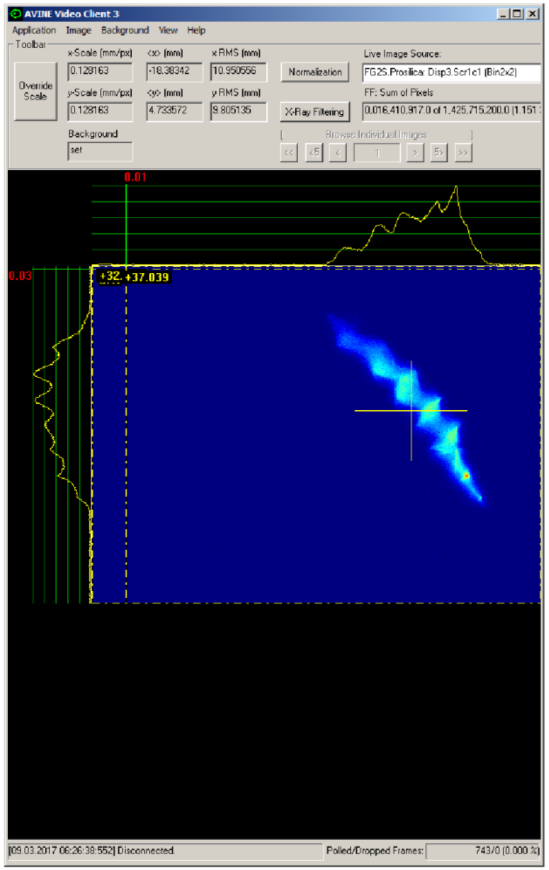
- Efficient transport of 1.1 nC through the coated (.9 mm inner diameter) tube (for nominal gun power 60 MV/m) at 12~ps flat top- best so far ! (90%+)
- Led to best bunching too.





Progress

- Propagation to the LPS successful, clearly see a semi-staircase bunch.
- Shown for 45 MV/m in the gun. Now repeating for 50 MV/m .



Next steps

- What is optimal configuration for bunching?
  - IF we lower gun energy, we can put less charge into the structure, however the R56 will be bigger which will allow bunching to happen more quickly. We are also prone to more energy spread.
  - We can run the gun at nominal power and fit *more* charge through the structure (1.1+ nC) and play with the booster power to delay the acceleration and e.g. give the bunching more time
  - These steps take time in implementing, what is easiest approach?
  - Astra simulations are being worked out to help guide us.
- Now running at 50 MV/m ; today try to optimize the transmission through the structure and characterize bunching and peak currents.

For next days

- Finish/inspect 50 MV/m.
- Return to 60 MV/m if bunching is not improved
  - Reduce booster to maximize bunching at LPS
  - Take a good data set..

Thanks!

- Thanks for your excellent and hard work..