Beam ‘modulation’ on TDS screen

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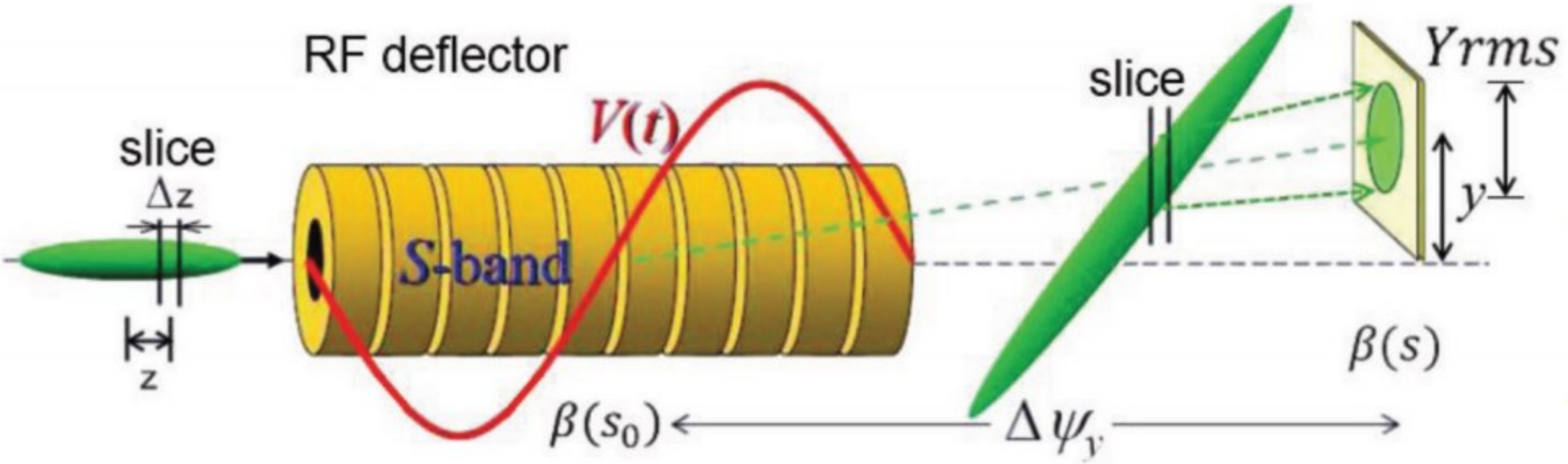
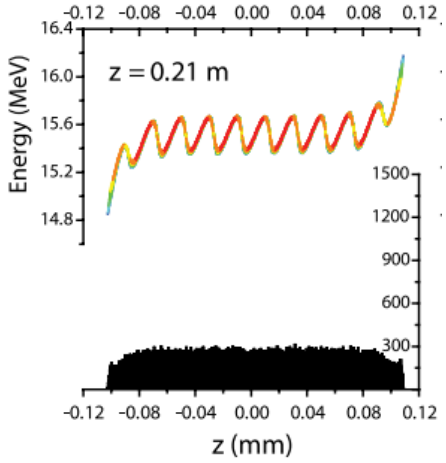
TDS & s parameter



$$y = S \cdot z = \frac{eV_0 k}{pc} \cdot L \cdot z$$

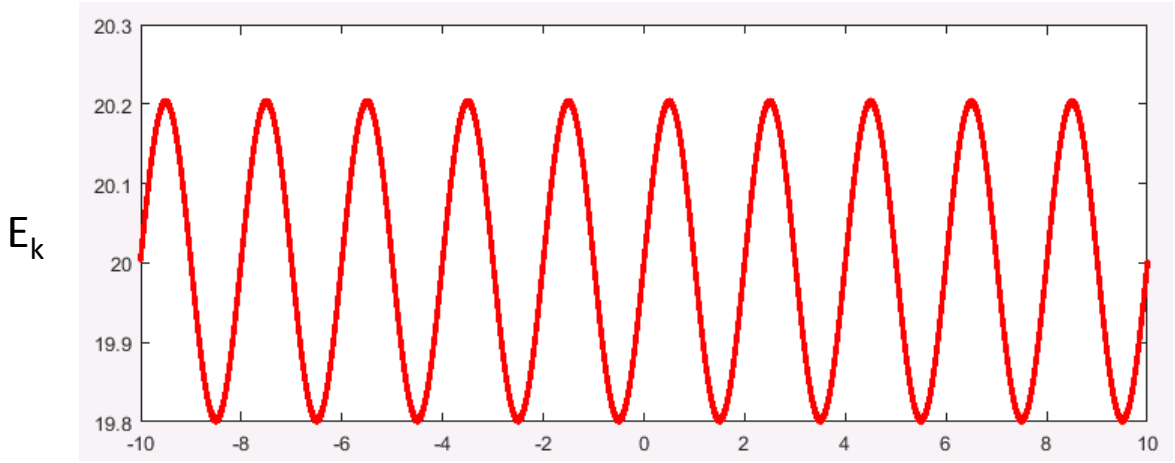
Energy modulation from longitudinal space charge oscillation

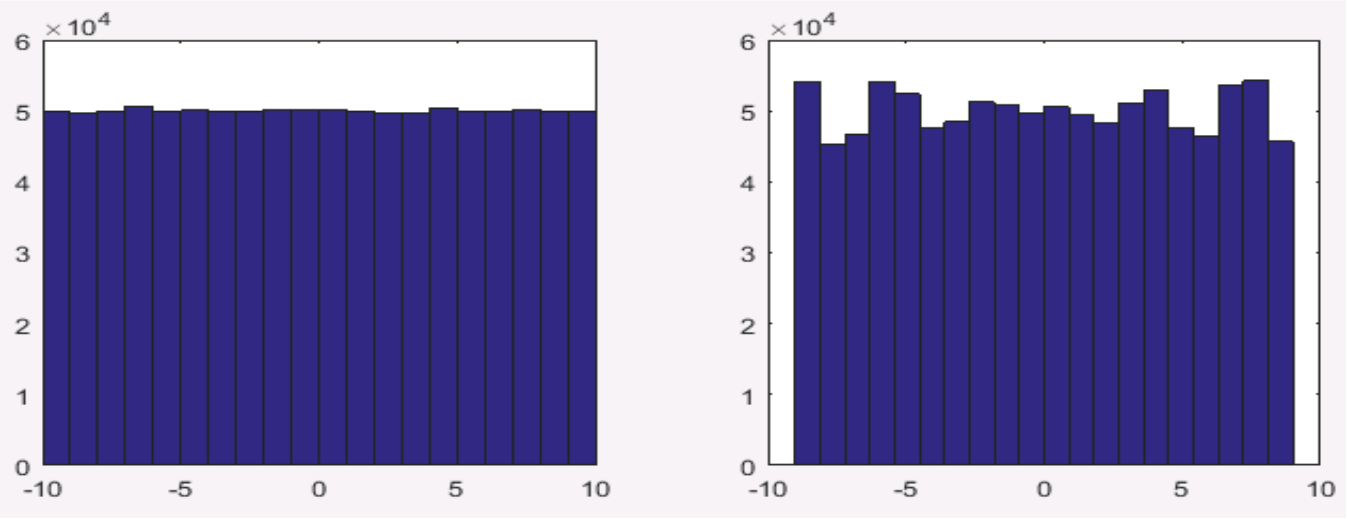
- UCLA paper: Nonlinear Longitudinal Space Charge Oscillations in Relativistic Electron Beams
  - cathode (z=0), laser bunch modulation
  - Smooth current distribution at z=0.21 m
    - 0.2 MeV energy modulation amplitude



Matlab simultion

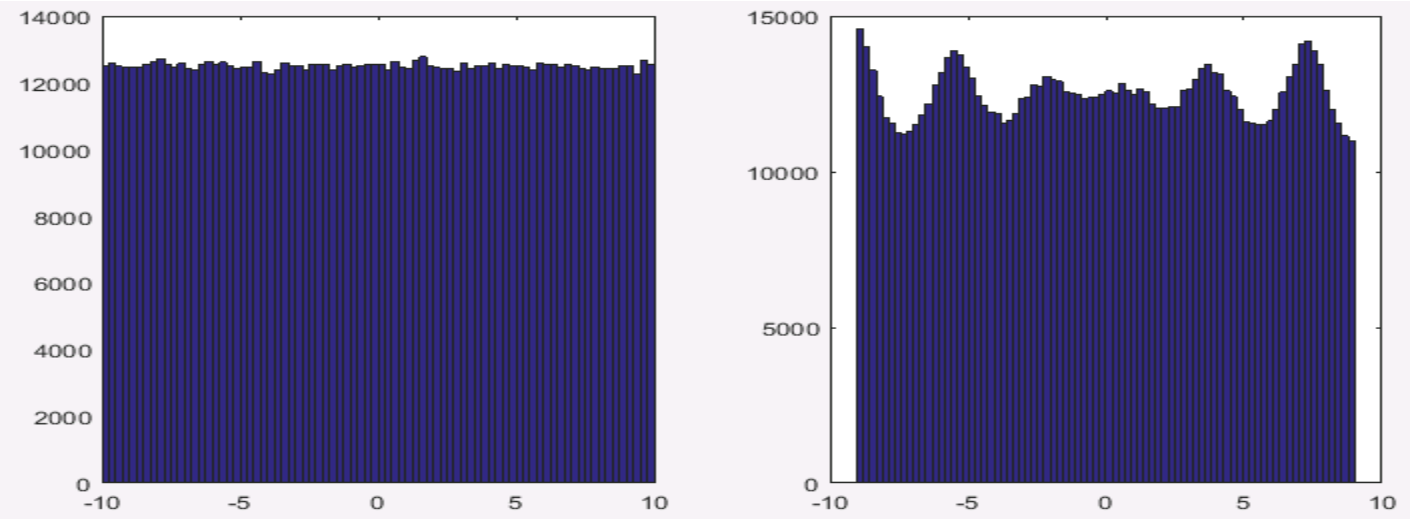
- Assume a 20 MeV beam with 5 keV slice energy spread and 200 keV enegy modulation with 4 ps period
  - Longitudinal phase space





t y

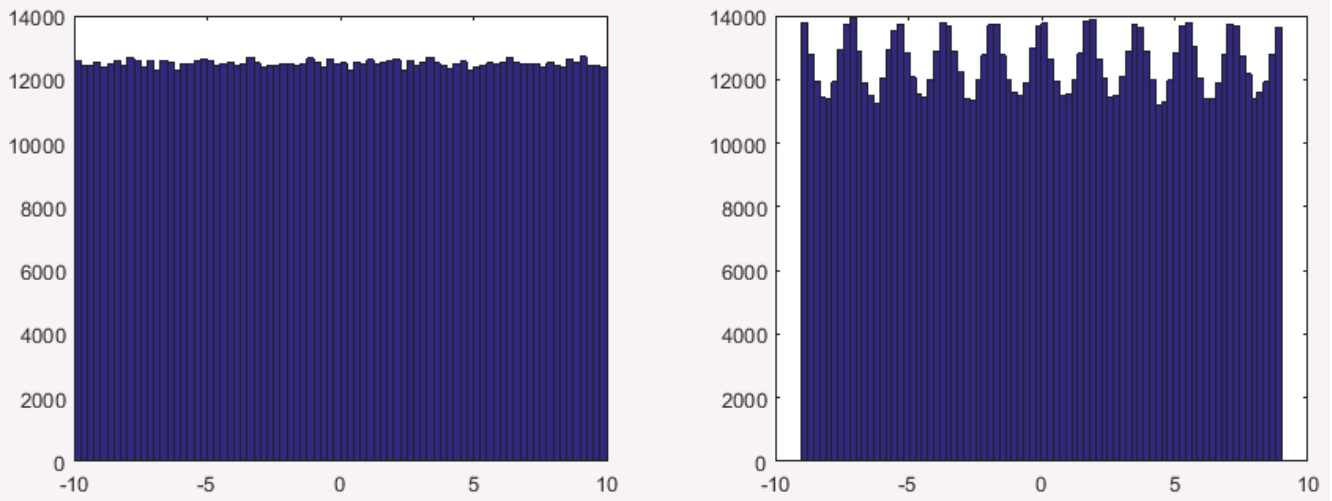
TDS, 1 ps resolution



t y

TDS, 0.25 ps resolution

- 1 mrad dc dipole kick (assuming 3 meter away from TDS screen, removed TDS effect from previous slide)



Analytical analysis

- With no energy modulation
  - $S=S_0$
- With high frequency energy modulation

$$E_{\mathrm{mod}ulation} = E_0(1 + a\sin(kz))$$

$$S = \frac{S}{S_0}S_0 \approx \frac{S_0}{1 + a\sin(kz)} \approx S_0(1 - a\sin(kz))$$

$$TDS\ screen: y = Sz = S_0(z - az\sin(kz))$$

Modulation with slope seen on TDS screen
It changes when you change TDS phase away from zero crossing

Analytical analysis

- With DC kick and high frequency energy modulation

Transverse dispersion at TDS screen

$$TDS\ screen: y = Sz + D\frac{\Delta p}{p} = Sz + D_y a\sin(kz)$$

$$= S_0(z - az\sin(kz)) + D_y a\sin(kz)$$

Uniform modulation seen on TDS screen
It changes when you go to different TDS slope

Analytical analysis

- With RF dipole wake generated from wakefield structures

$$TDS\ screen: y = Sz + b(z)\sin(k_2 z)$$
$$= S_0(z - az\sin(kz)) + b(z)\sin(k_2 z)$$

Non-uniform current modulation seen on TDS screen
It changes when you go to different TDS slope