Some Applications of Seeded Microbunching with Collective Effects

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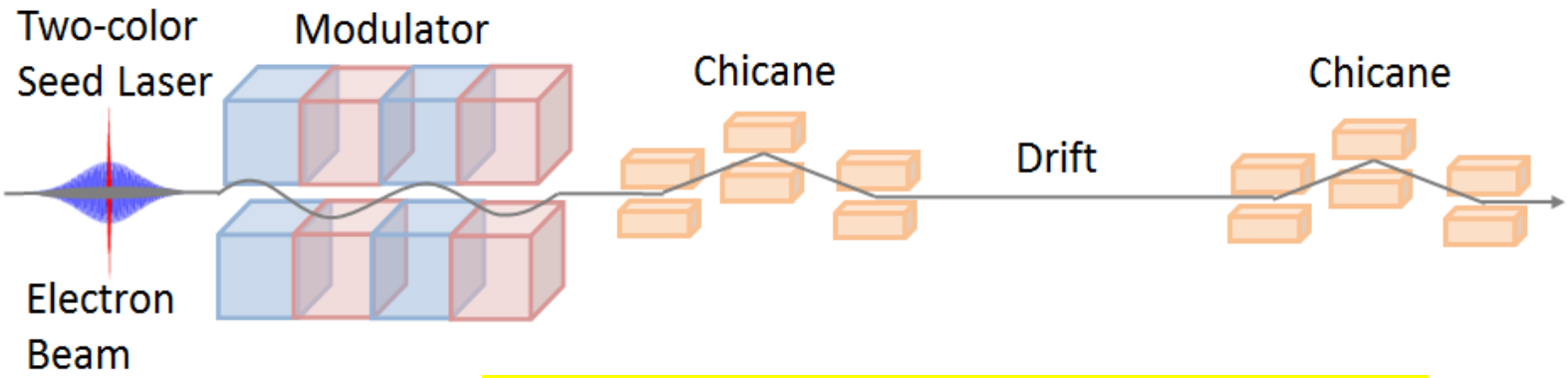
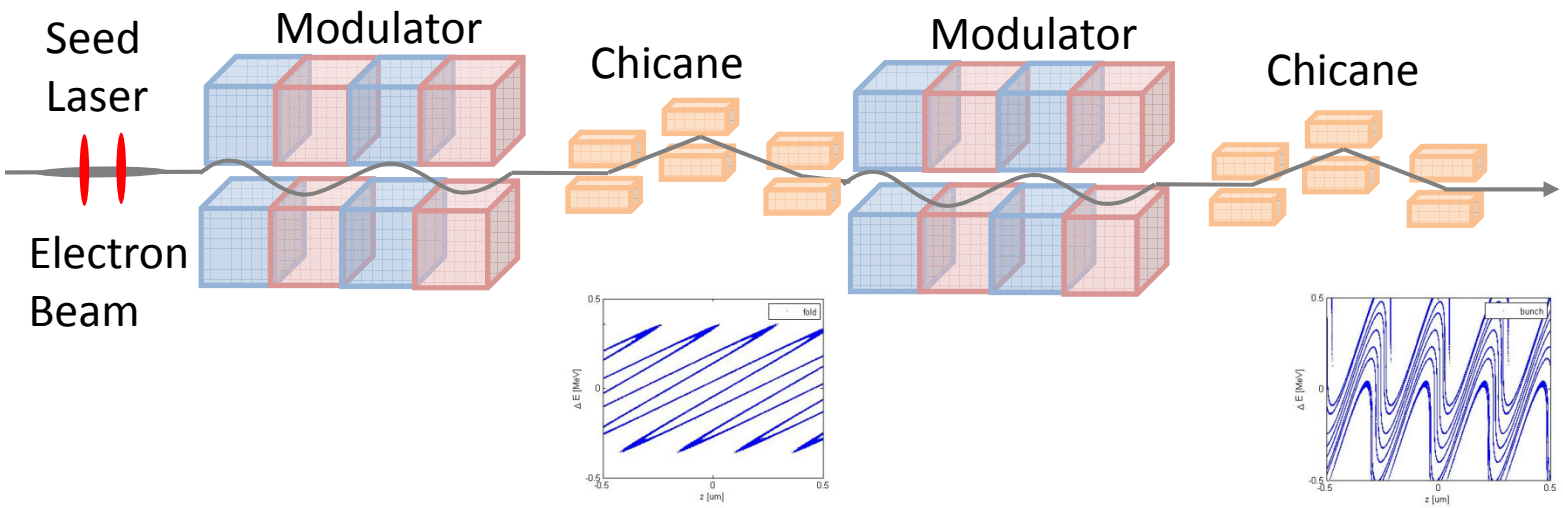
- LSC EEHG seeding
- CSR, LSC and longitudinal phase space distribution measurements with an RF deflecting structure dipole spectrometer
- How to compress a seeded microbunch?
  - CSR in a chicane
  - LSC in a drift

LSC - EEHG

New seeding concept (PRSTAB Sept 2014)

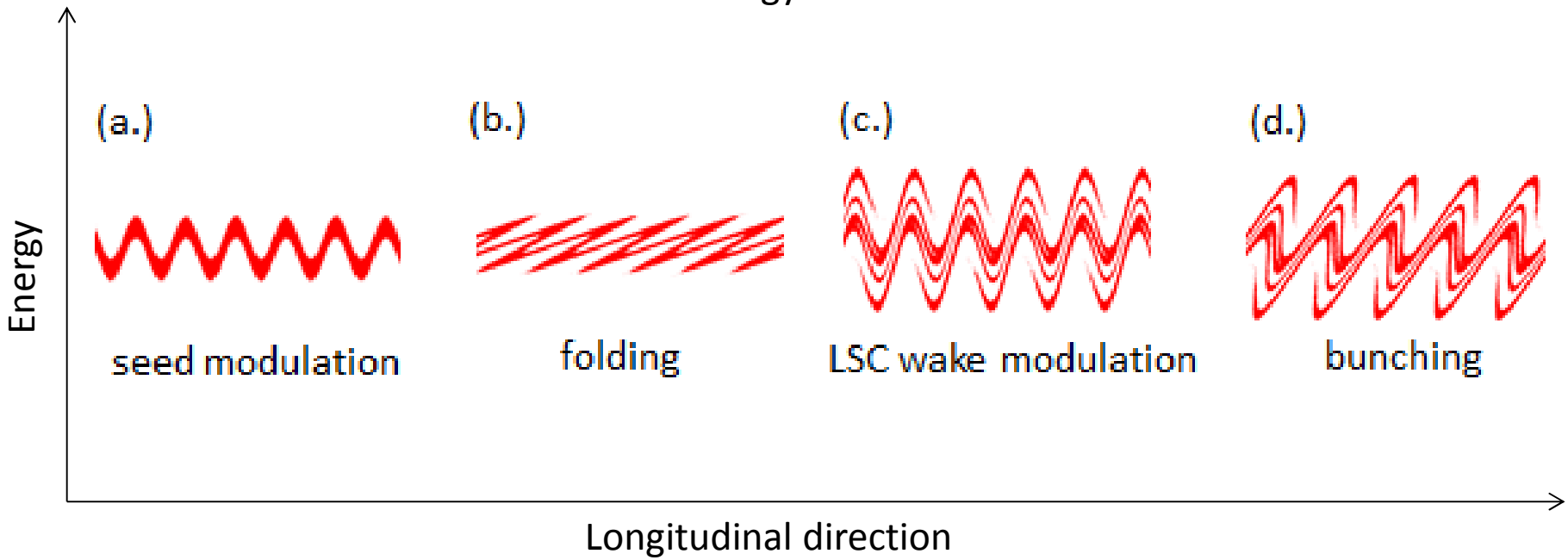


Original seeding concept (Stupakov PRL 2008)



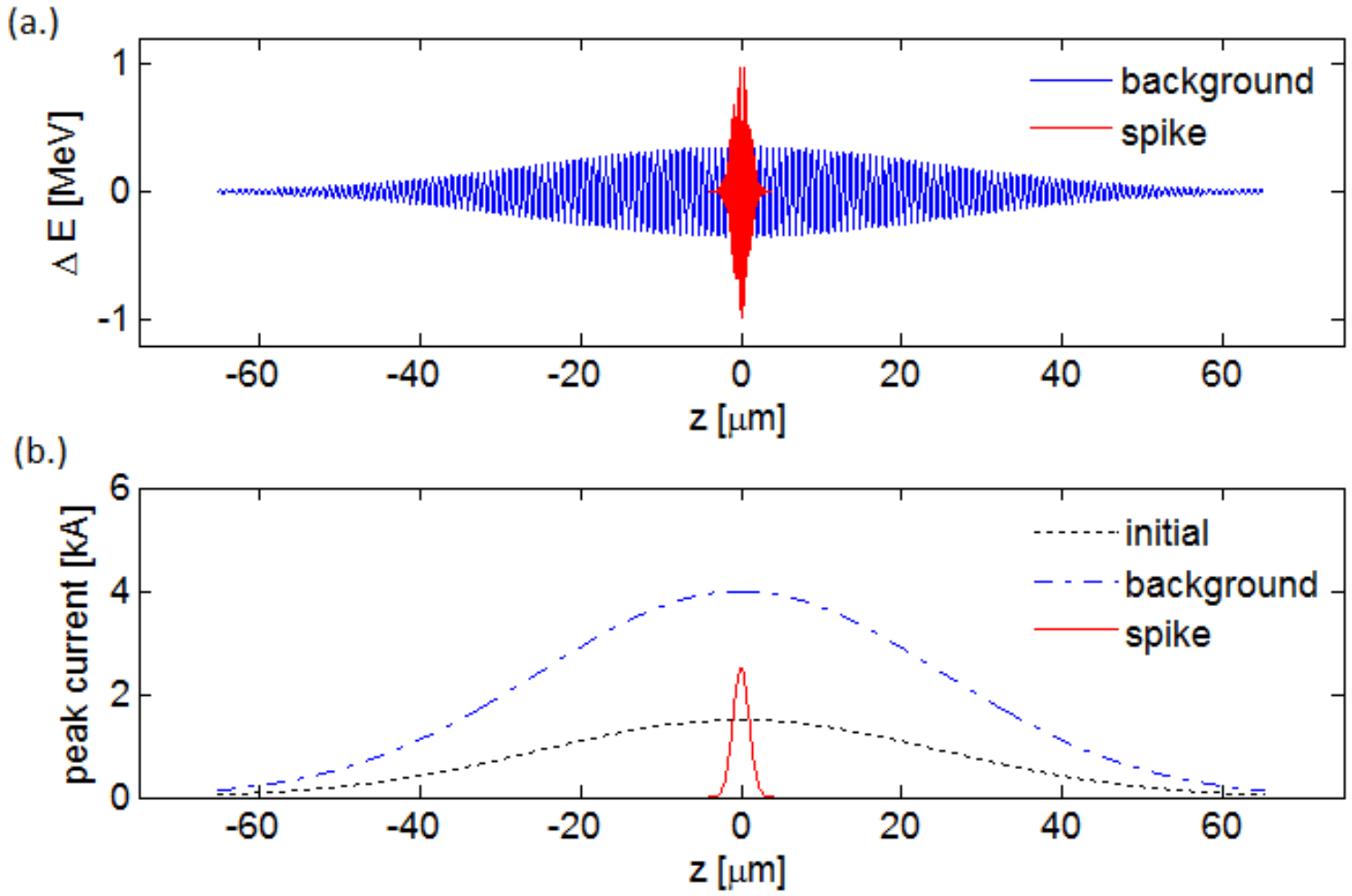
LSC-EEHG

1.5 kA, 150 keV, 0.9 GeV
2 MeV energy modulation

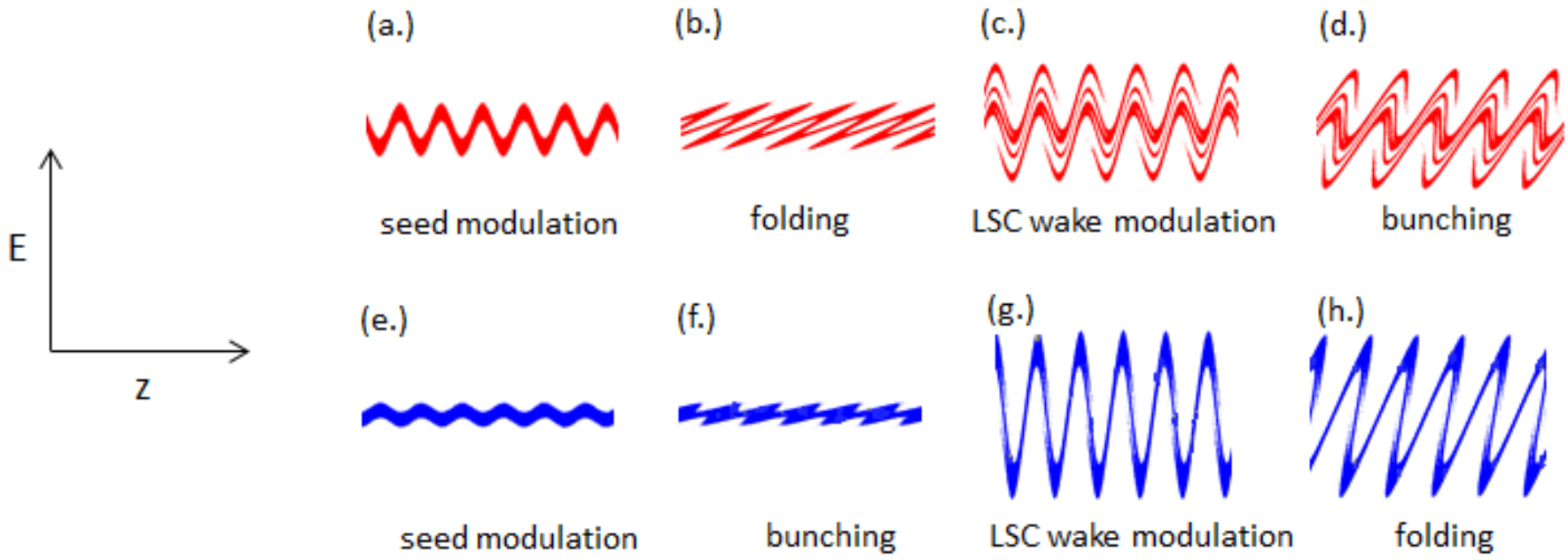


Spike lases, background doesn't

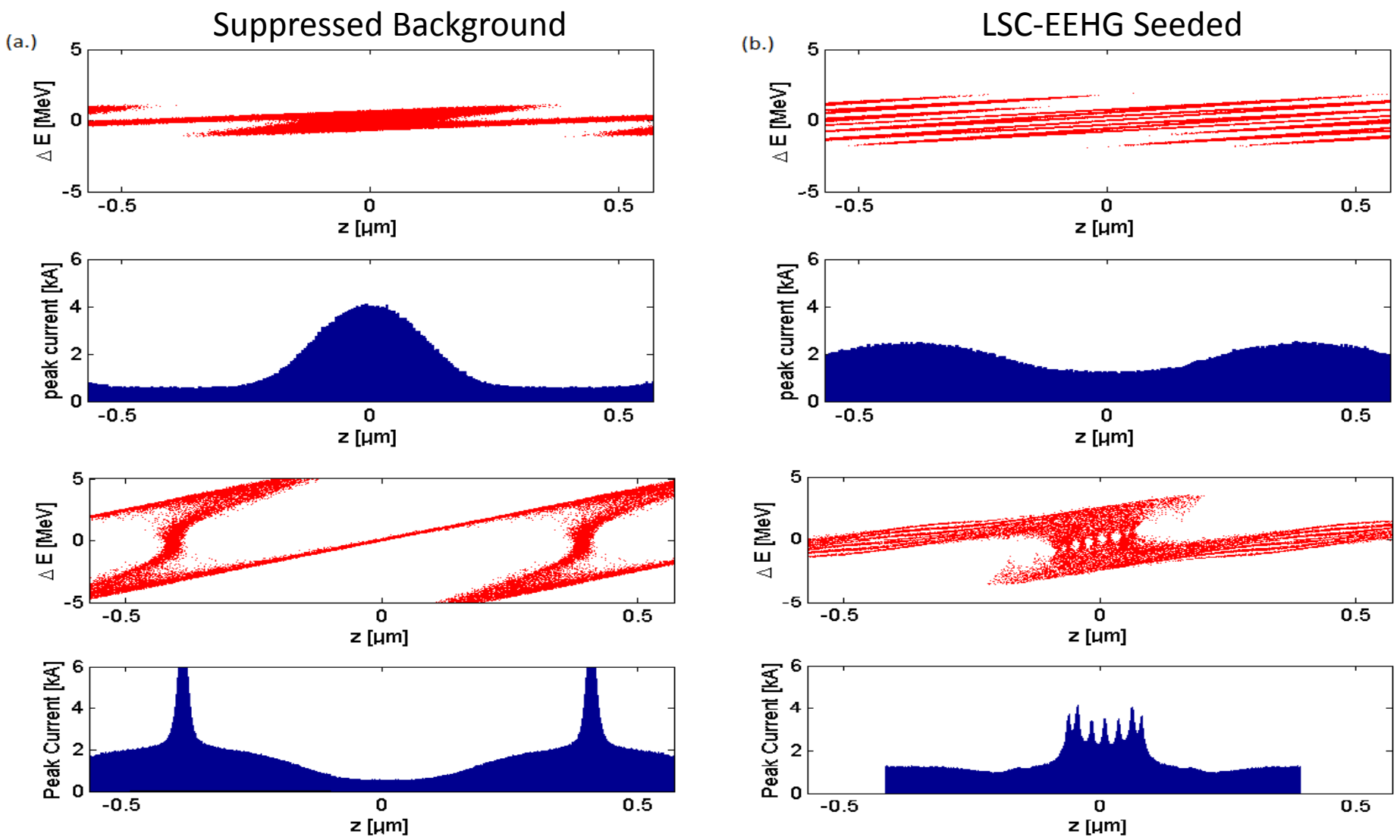
Suppression of SASE lasing background



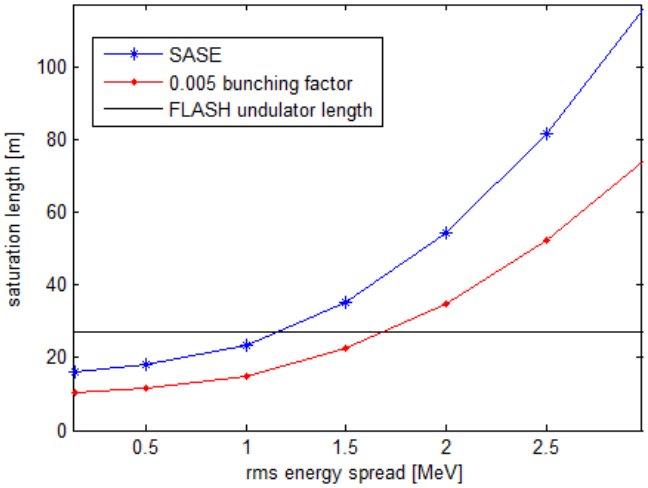
LSC-EEHG with SASE lasing suppression

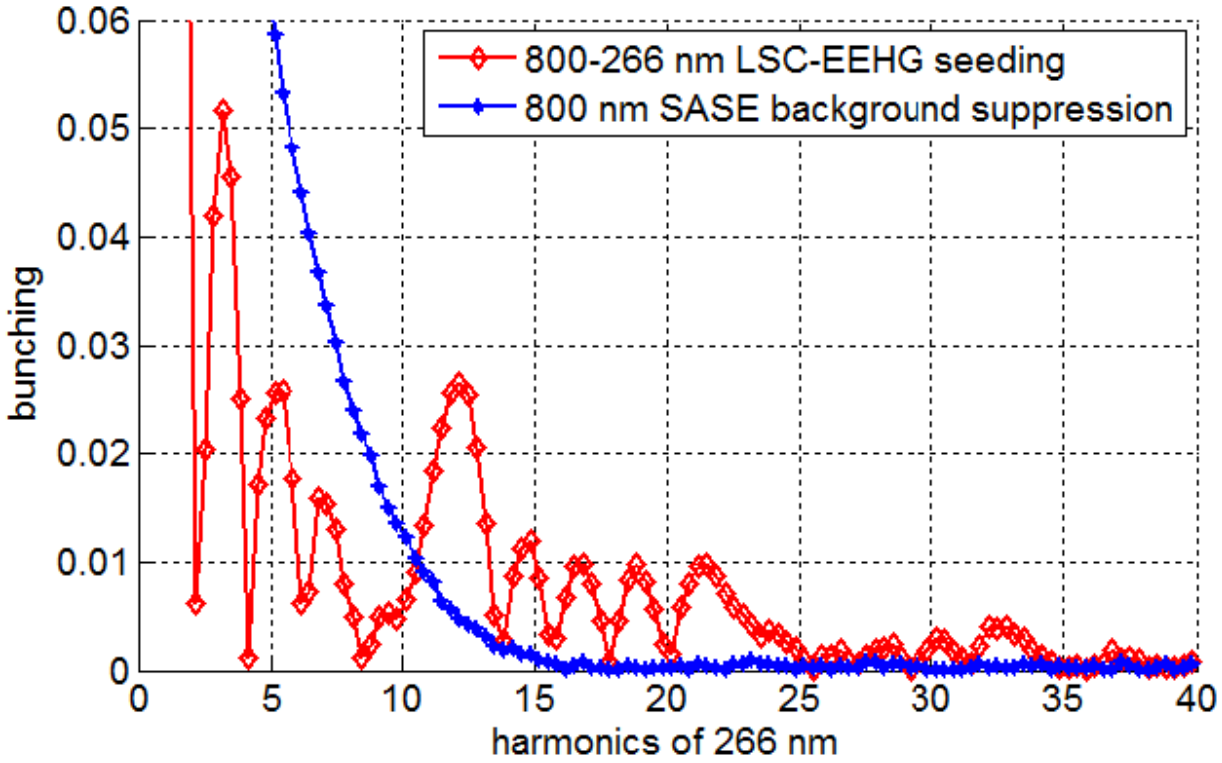


Two-color concept



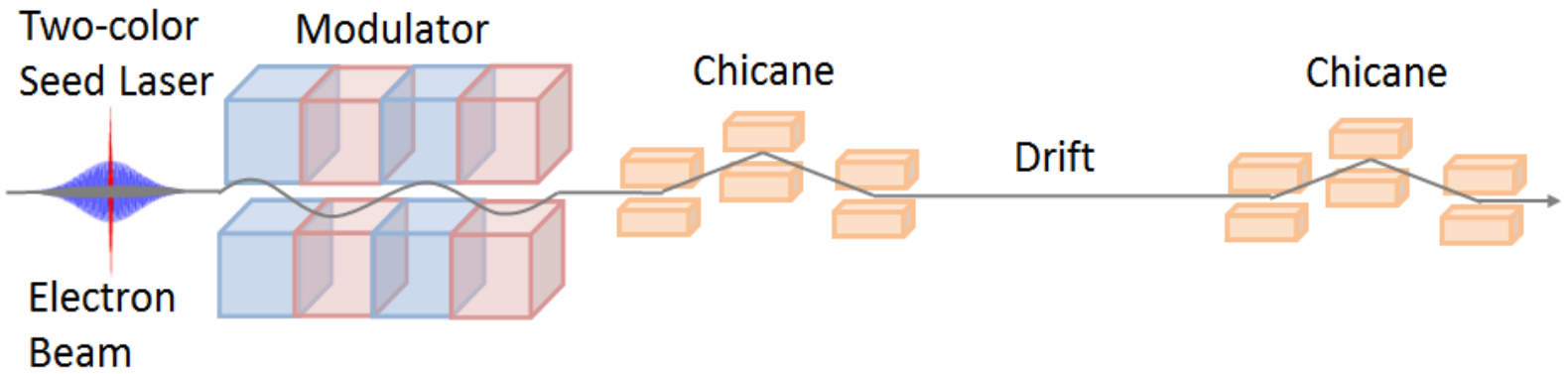
The spike lases, the rest doesn't



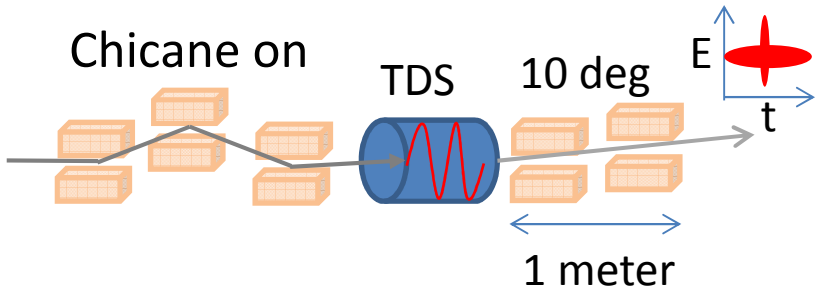


Tuning knobs

- Energy modulation amplitude
- R56
- R53, R54
- Beam radius in drift



Longitudinal Phase Space Distribution Measurement with TDS and Dipole Spectrometer



Claim: Microbunch CSR was wrongly discounted as a relevant error source.

Claim: Microbunch LSC effects are also a significant error source.

Slice Energy Spread Errors

- Added energy spread from RF @ 1GeV

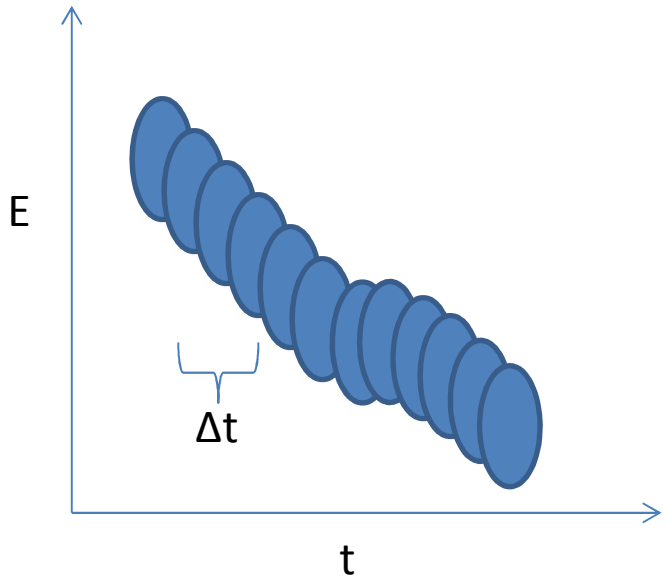
  $=\frac{\epsilon_n}{\gamma c \Delta t}$ where $\Delta t = \frac{\sigma' \lambda_{rf} E}{2\pi c e V}$ is 15-30 fs

  =100-250 keV

- spectrometer resolution

  $= \frac{\epsilon_n \beta}{2\gamma\eta^2} \sim$ 50-300 keV

- correlated energy spread

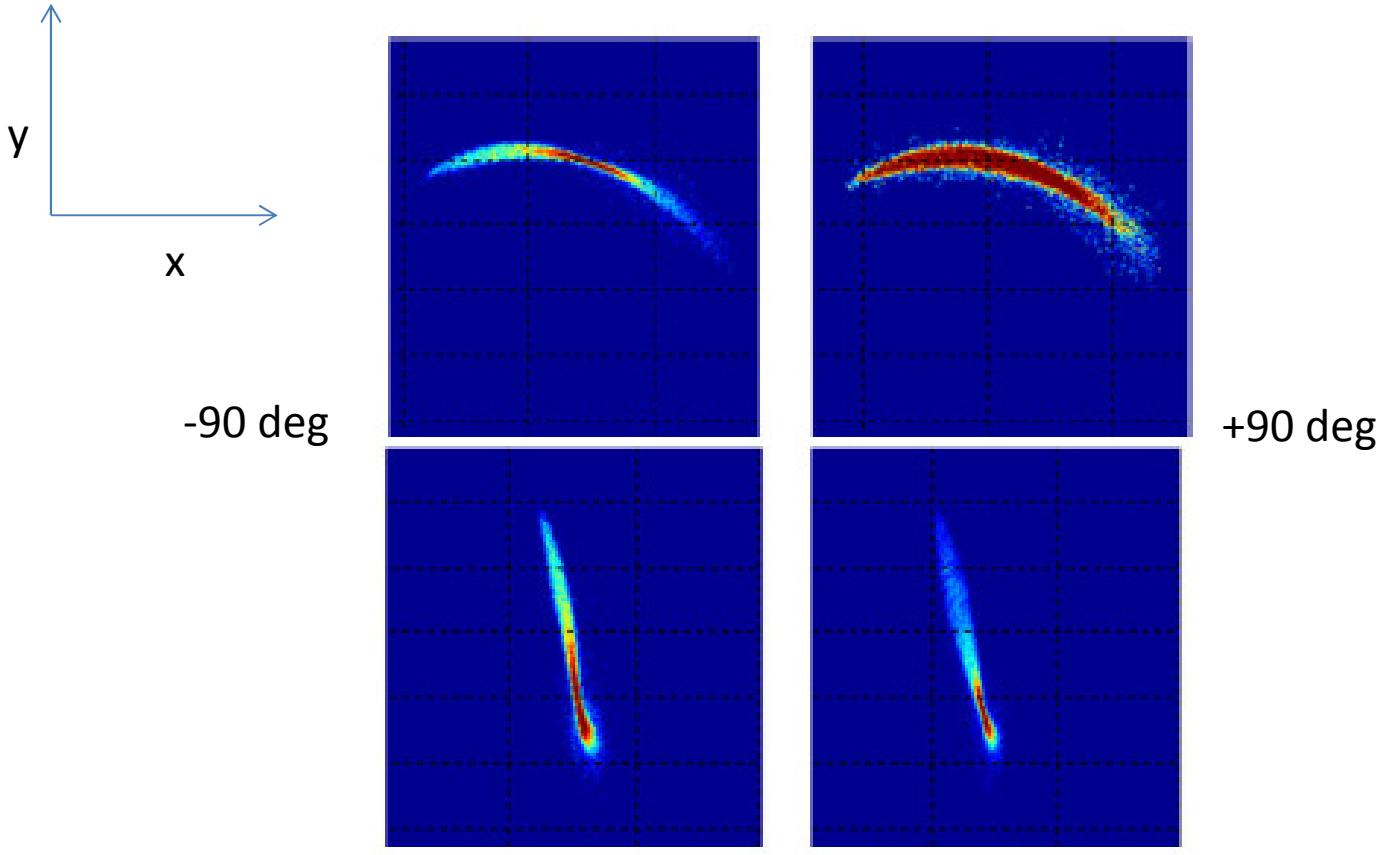


D. Xiang, 2011 SLAC-PUB-14615

2012 Data from DESY

S2E Meeting 8th of March 2012

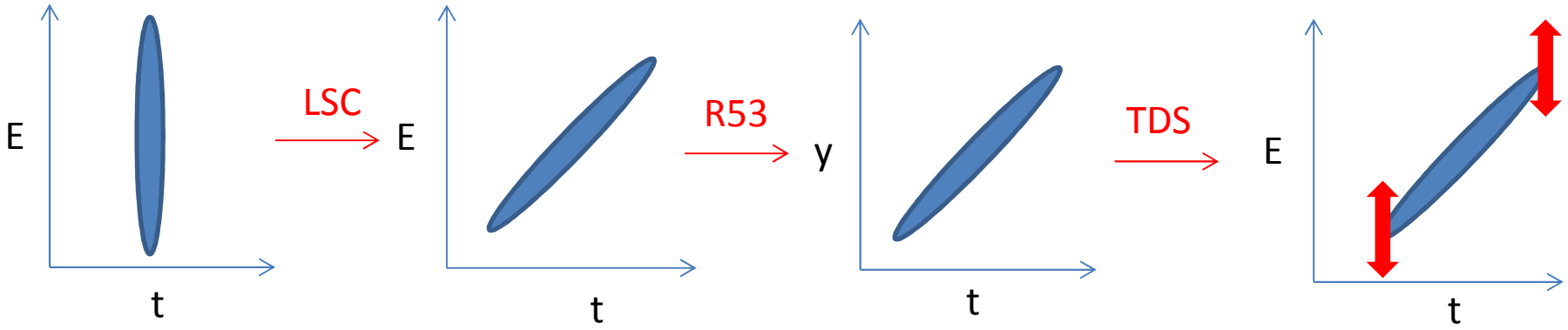
H. Edwards, M. Yan, A. Langner, C. Schmidt, M. Vogt, M. Dohlus



Correlations in y-t (energy spread error)

PRSTAB 15, 022802 (2012) describes reversible heating on the macrobunch scale

I claim that it is happening on microbunch scale



RF transfers energy depending on vertical position

This will influence the microbunch energy-time correlation measured with the spectrometer

This will thereby influence the slice energy spread

This error can be removed by averaging the two flipped phase measurements.

Correlation in x-t (bunch length error)

SLAC-PUB-9241
May 2002
Eighth European PAC,
Paris, France, (2002)
R. Akre, L. Bentson, P. Emma, P. Krejcik
SLAC

Incoming Correlation + Streak

$$\sigma_{x_{error}} = (C_{xt} \pm S_{xt})\sigma_t$$

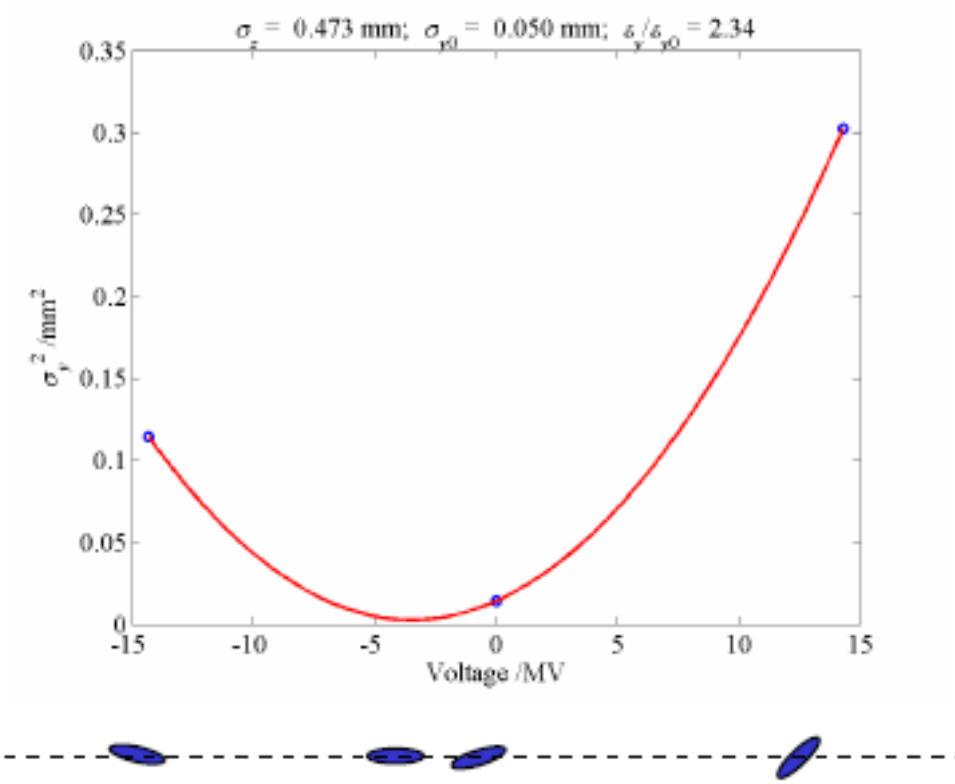
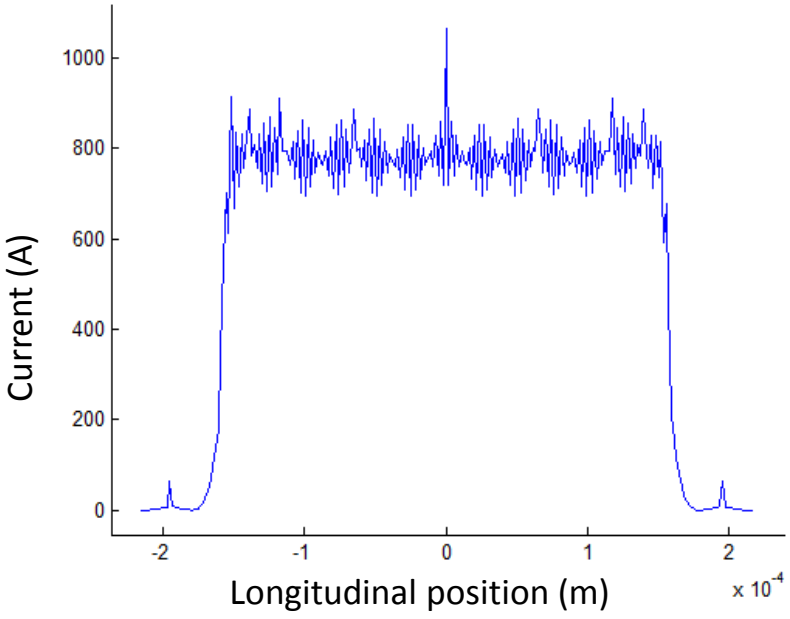
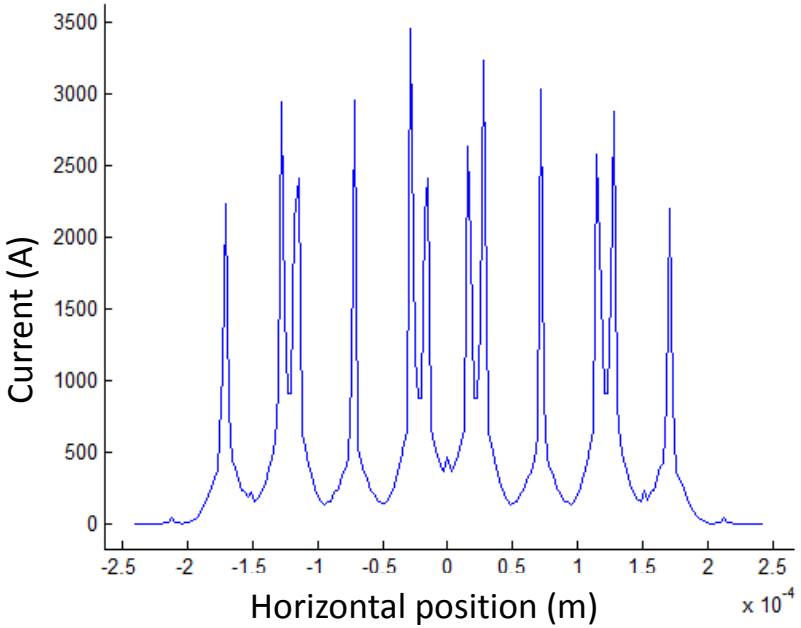


Figure 5: An asymmetric beam size scan with RF voltage indicates an incoming transverse-longitudinal correlation in the bunch, shown in the lower illustration, which is cancelled by the cavity at $V\left(\sigma^2_{y\min}\right)$.

CSR track (code from Dohlus)

Spectrometer after Transverse RF Deflecting Structure	
Number of dipoles	2
Angle	5 degrees
Length	500 mm
Radius of curvature	5.7 m
Dispersion	0.75 m

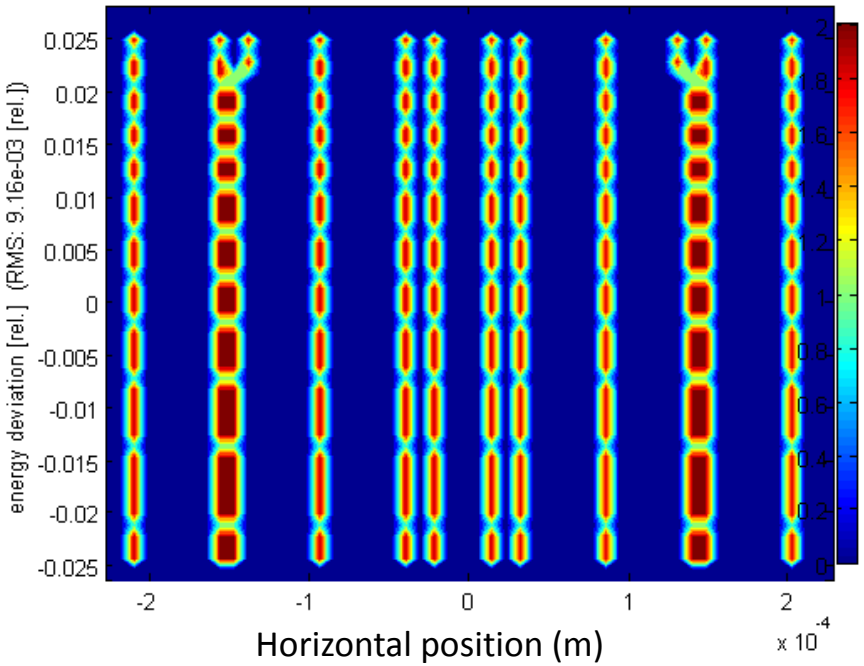




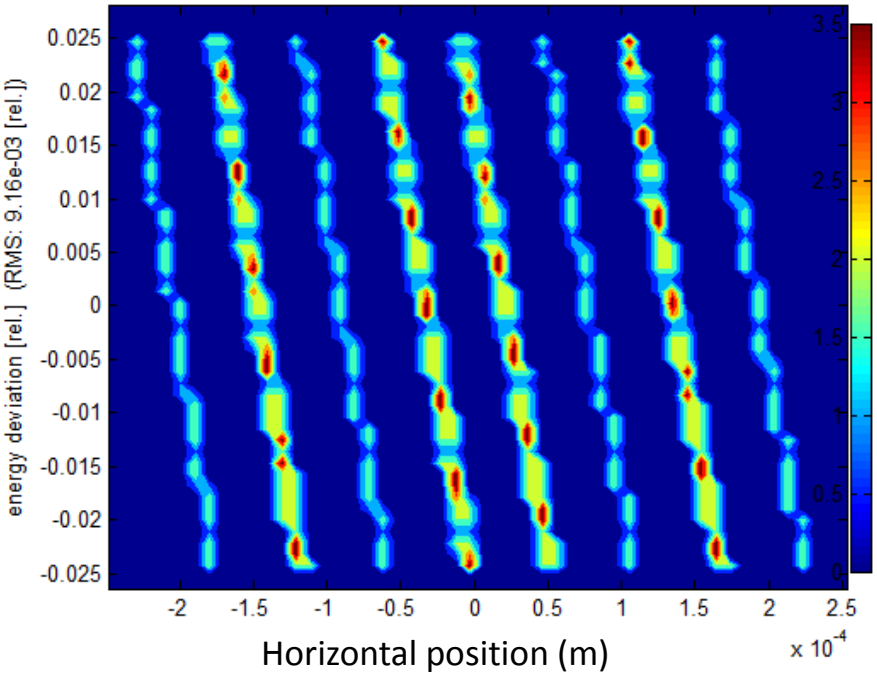
R51 smears out microbunches after ~100 mm

Therefore, we are only interested in CSR from this first 100 mm

After 50 mm



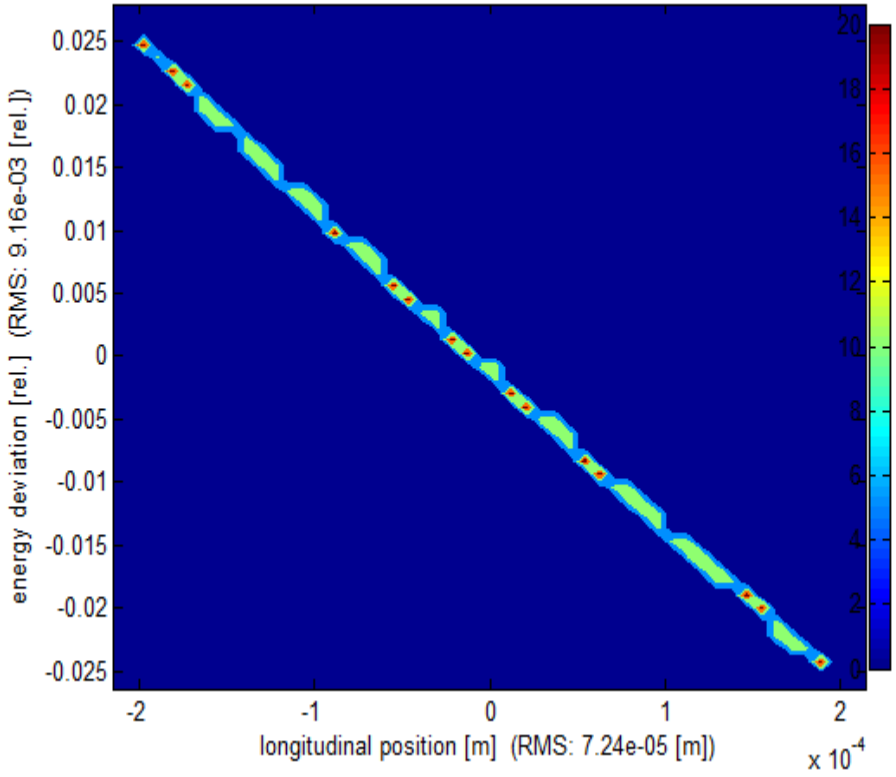
After 100 mm



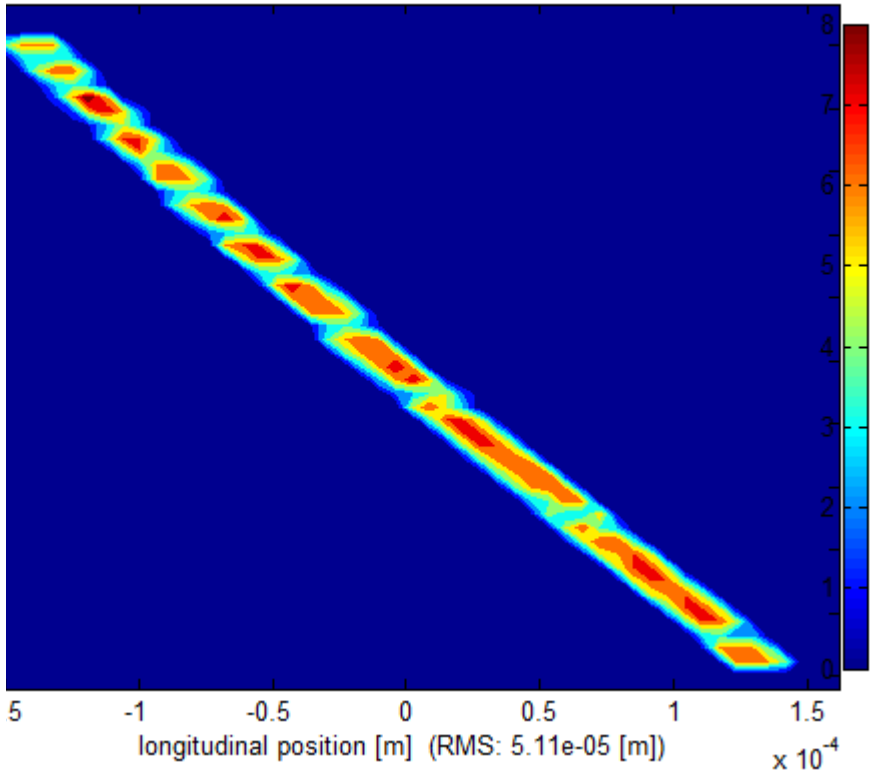
After CSR wake from first 100 mm

Maximum energy spread (steady-state) occurs after first 300 mm
70% of deflection has not yet taken place

After 0 mm



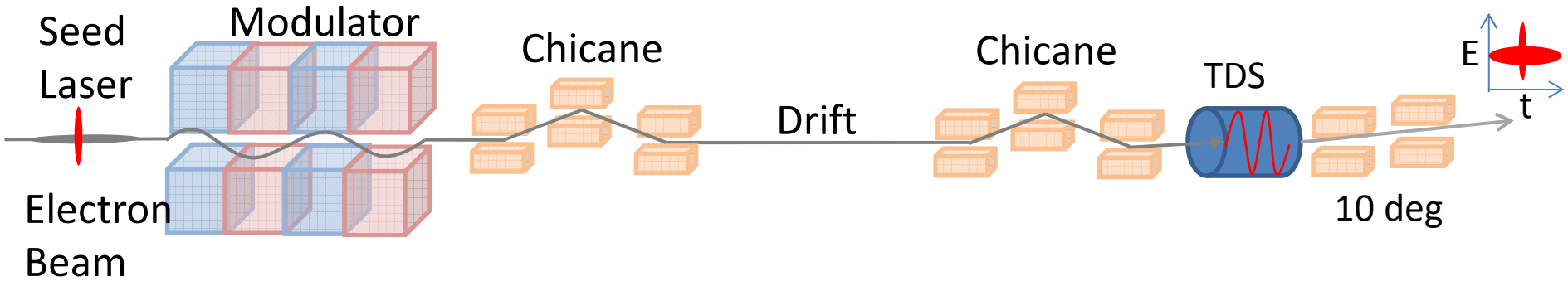
After 300 mm



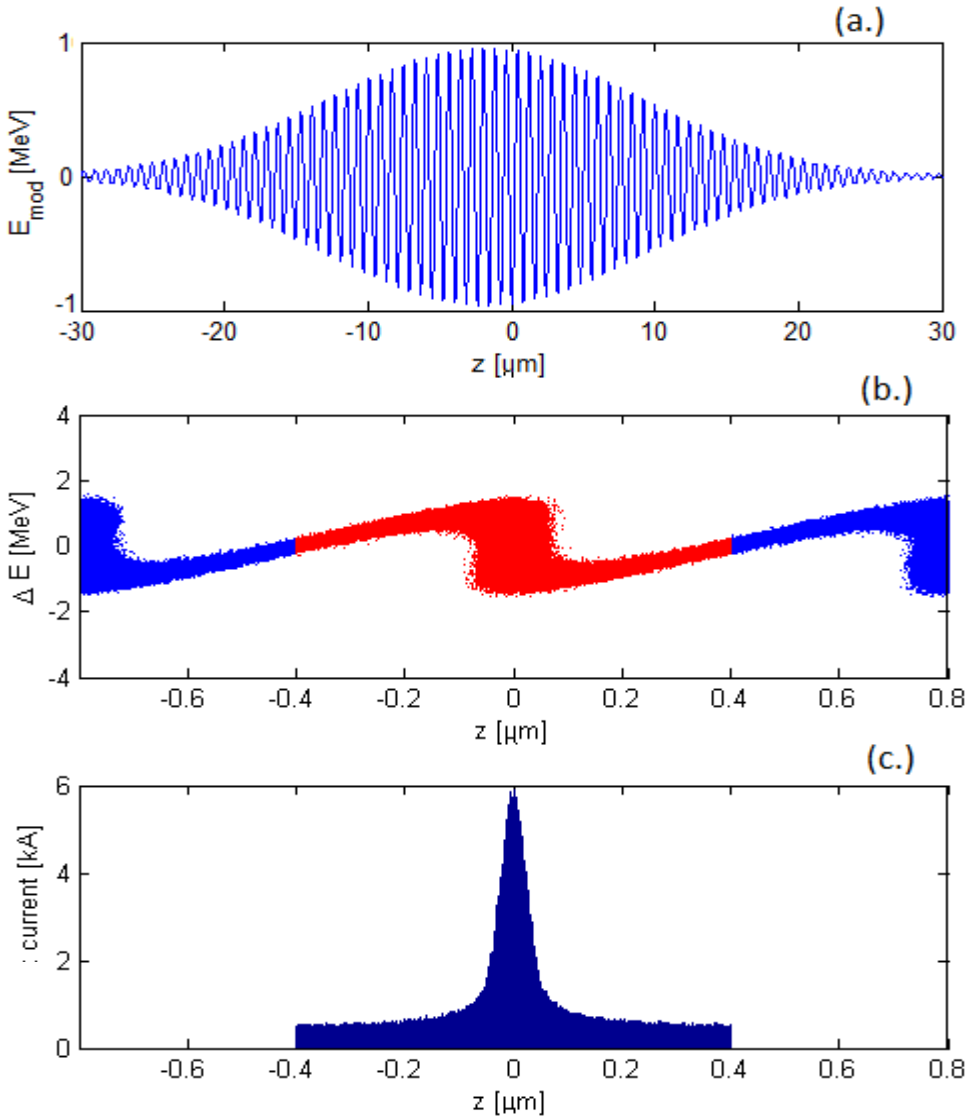
150 keV rms -> 1.5 MeV rms
70%*1.5 MeV = 1 MeV (rms)

How to compress a microbunch?

chicane (CSR) or drift (LSC)?



Imaginary Seeded Microbunch



Energy modulation
of seeded portion of bunch

Single seeded microbunch

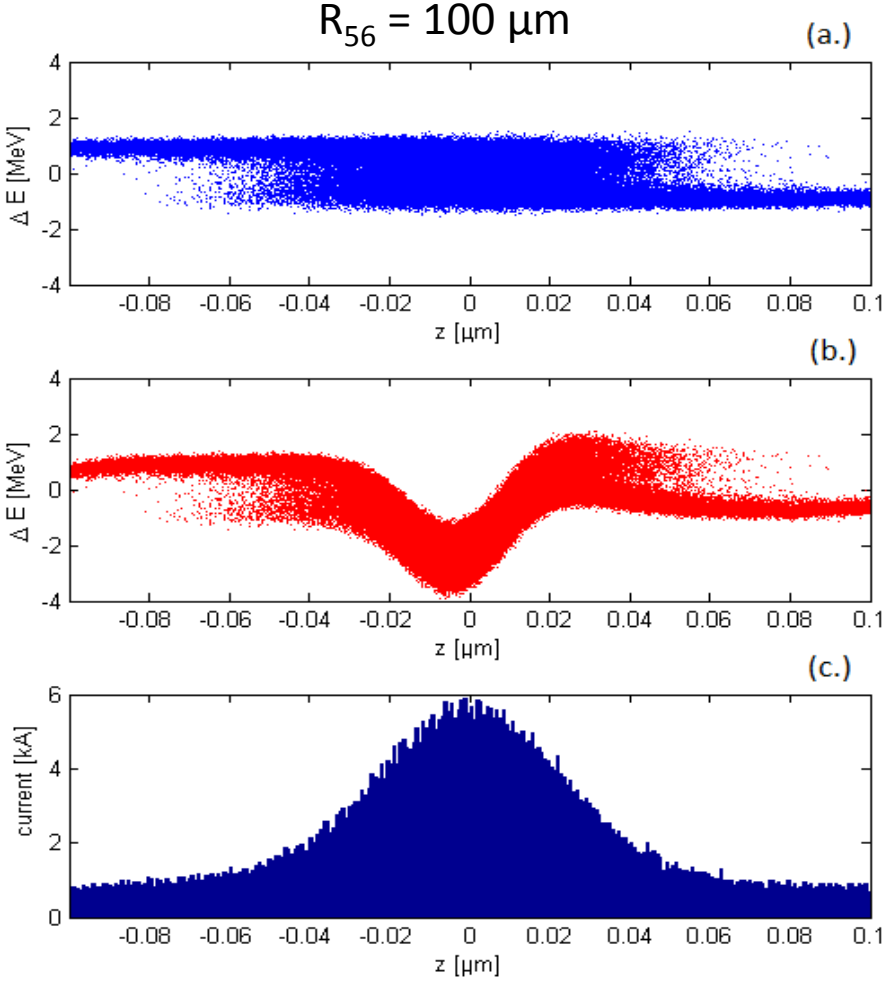
700 MeV, 1 kA, 150 keV

Current density of
single microbunch

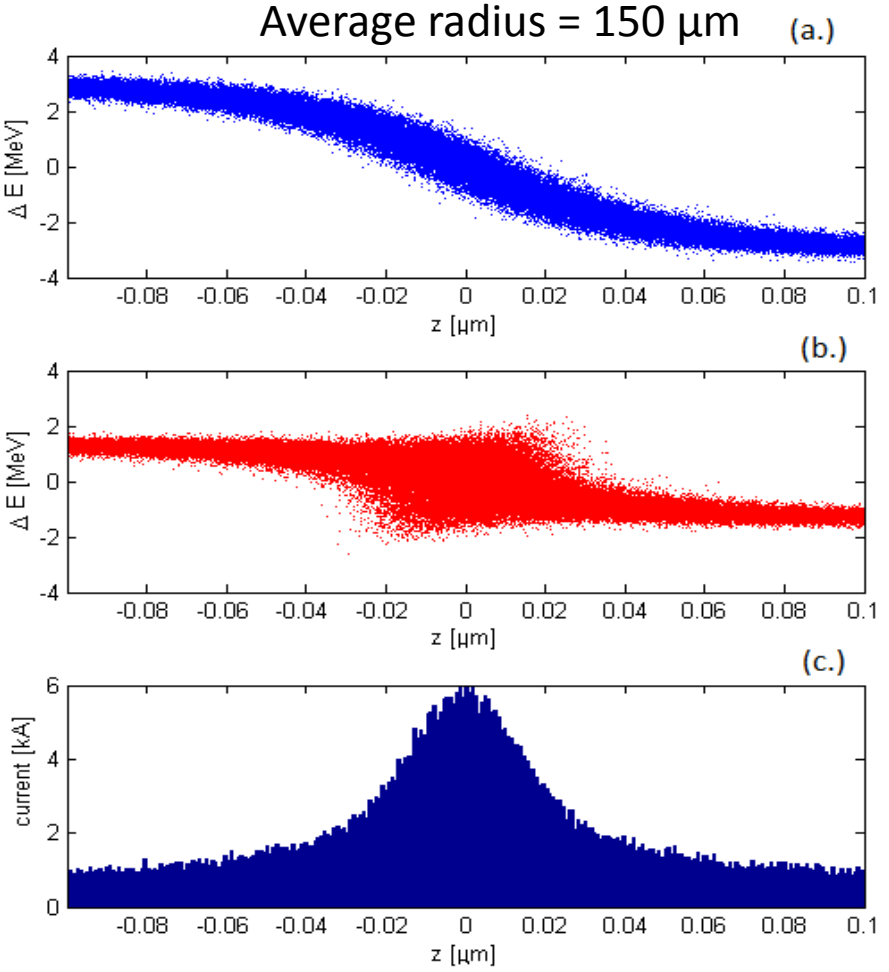
Chicane (CSR) or Drift (LSC)

700 MeV, 1 kA 150 keV

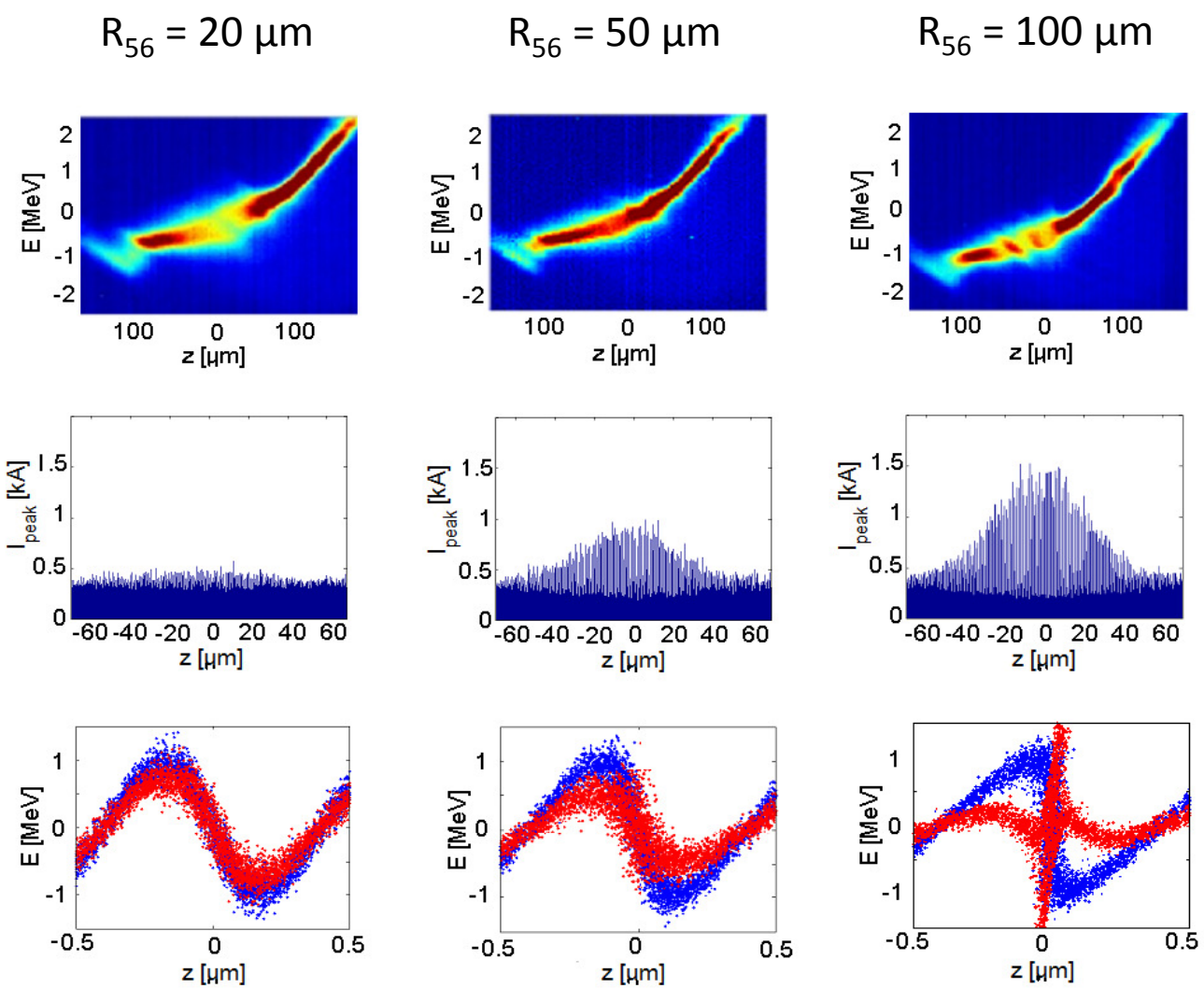
R_{56} = 100 µm



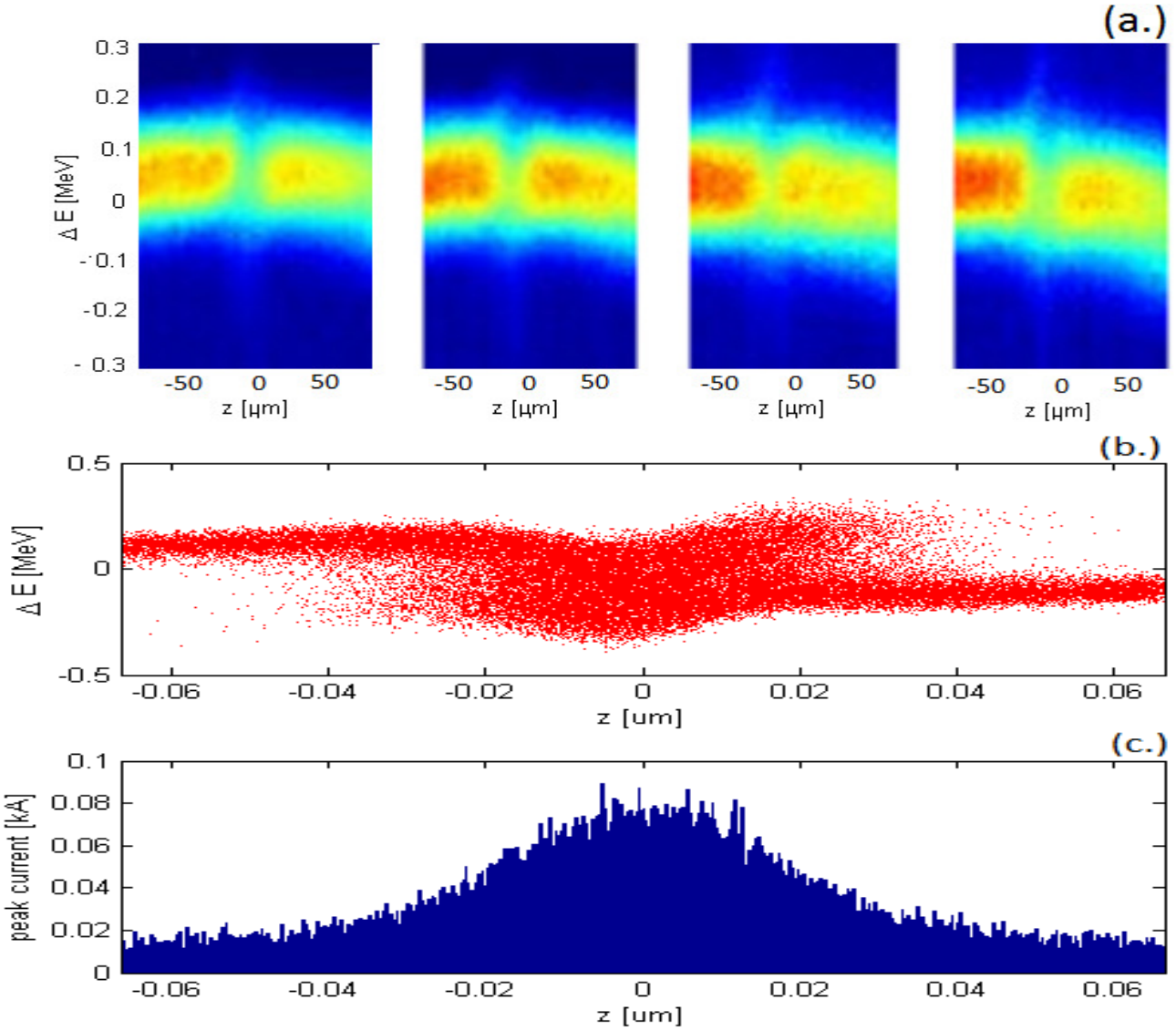
R_{56} = 20 µm
Length of drift = 20 m
Average radius = 150 µm



Measurement after a 25 meter drift



Measurement after a chicane



Conclusion

- Measurements of collective effects on seeded microbunches
- Longitudinal phase space measurements with transverse deflecting cavities are affected by microbunch CSR and LSC
- New seeding concept: LSC-EEHG