A bunch compressor for TBONE

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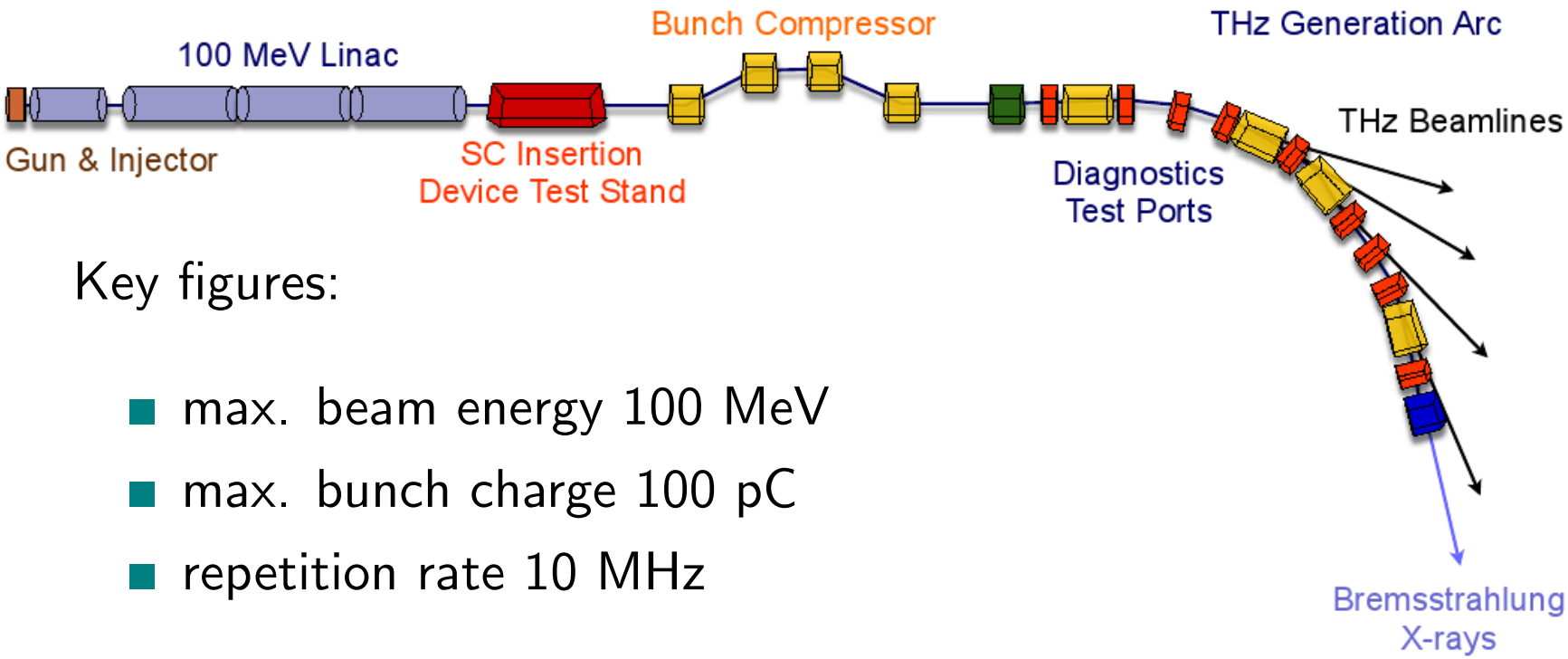
Outline

- **TBONE** - **T**Hz **B**eam **O**ptics for **N**ew **E**xperiments
  - The TBONE facility
  - The benefits of TBONE
- Principle of a bunch compressor
- Simulations / Major questions
  - Influence of CSR (Coherent Synchrotron Radiation)
  - Energy Jitters
  - Comparison of the two Tracking Codes CSRtrack and AT
- Summary

The TBONE Facility



Key figures:

- max. beam energy 100 MeV
- max. bunch charge 100 pC
- repetition rate 10 MHz

- frequency range 0.1 to 150 THz
- up to several MW peak power

- bunch length 5 fs

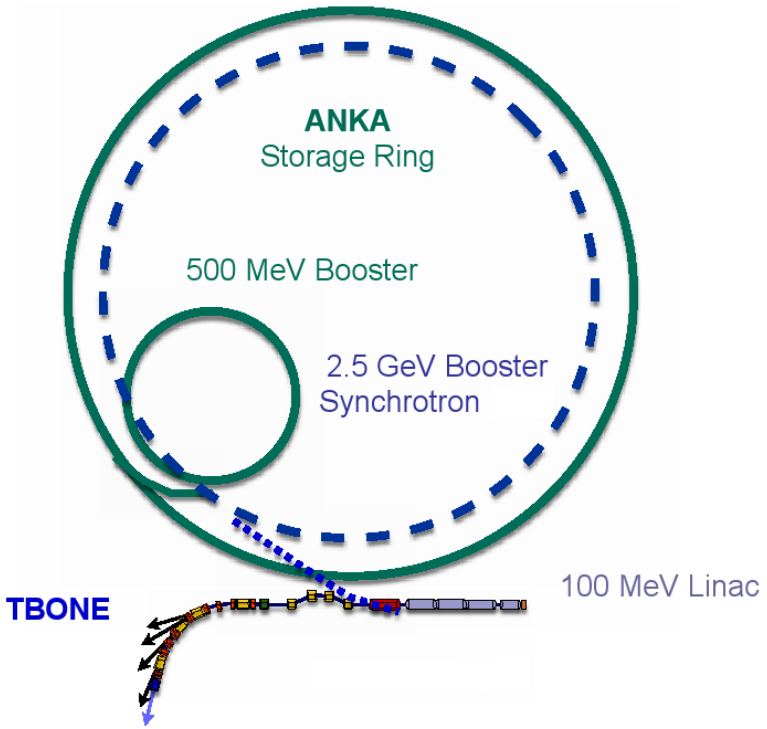
Benefits of TBONE

TBONE will offer

- instantanious broadband THz radiation,
- research posibilities on a fs timescale.

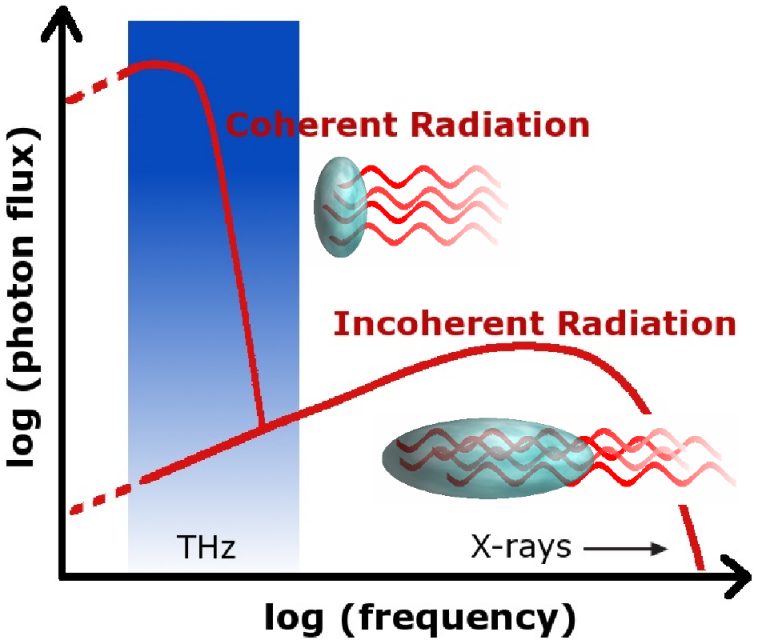
This will allow (e.g.)

- spacially resolved study of Cooper pairs,
- time resolved study of solvation dynamics,
- study of biological boundary layers,
- and much more.



TBONE could also be used as the first stage of a full energy injector to the existing ANKA storage ring.

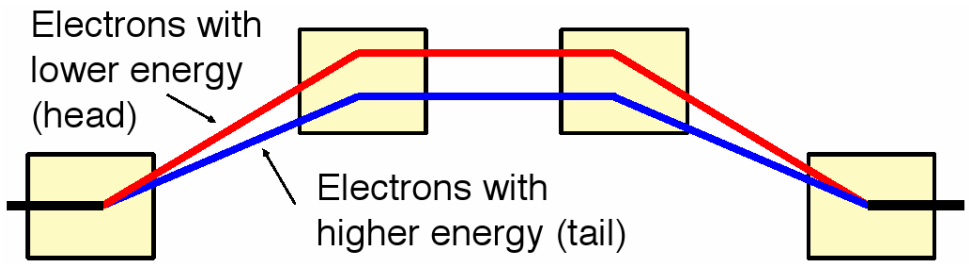
Why a Bunch Compressor?



- CSR is generated if electrons in bunch emit radiation in phase.
- This happens if bunch is of same length (or shorter) than wavelength of emitted radiation.
- $f = 150\,\mathrm{THz} \Leftrightarrow \lambda \approx 2\,\mu\mathrm{m} \approx c \cdot 5\,\mathrm{fs}$
- Radiation as CSR from bending magnet

- And, of course, new research posibilities on fs timscale...

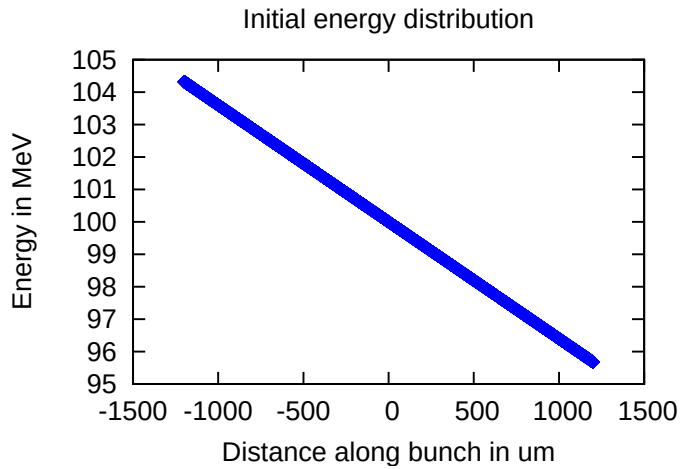
Principle of a Bunch Compressor



- Electrons with higher energy have higher relativistic mass $m(E)$.
- They have a smaller curvature $1/r(E)$ in the magnets,

$$r(E) = \frac{m(E) \cdot c}{B \cdot e}$$

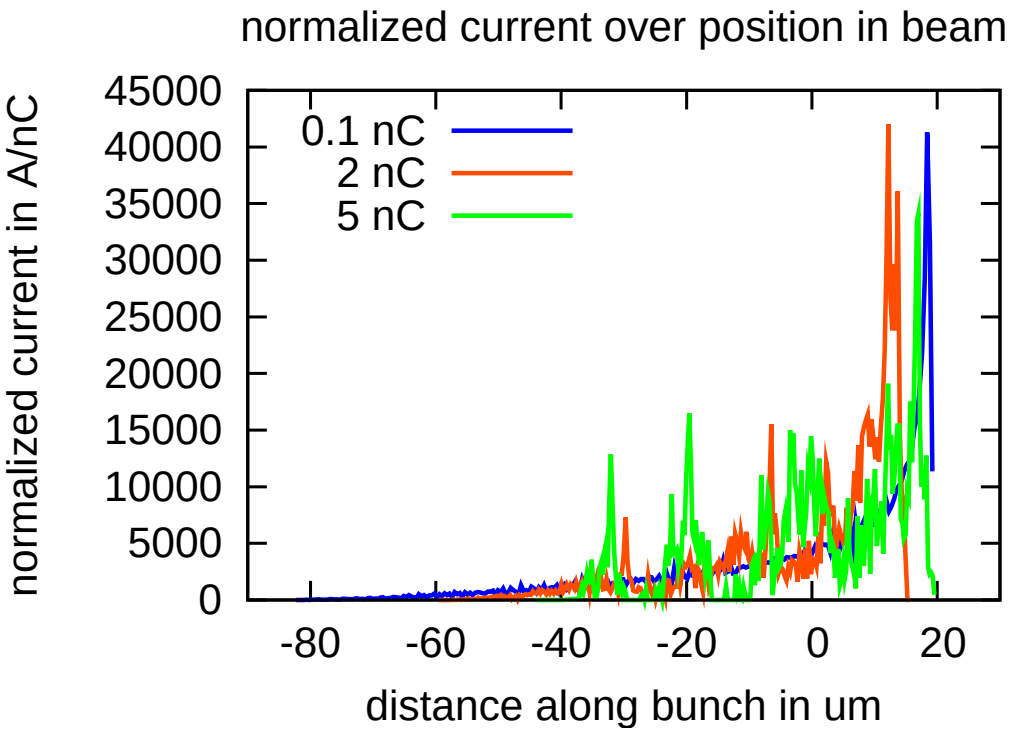
- Compression is achieved through path length differences.



above: idealised case with linear E-z-correlation

Influence of CSR

The influence of **C**oherent **S**ynchrotron **R**adiation was studied:



Above:
Current distribution is normalized with bunch charge.

- Bunch charge was varied ($CSR \propto N^2$).
- CSR effects become relevant for bunch charge over 1 nC.
- Planned bunch charge is only 0.1 nC.

Energy Jitter - Time of Arrival

The path length for particles was calculated depending on their γ.

For an energy $E_0 = 100\,\mathrm{MeV}$ this yield run time differences of

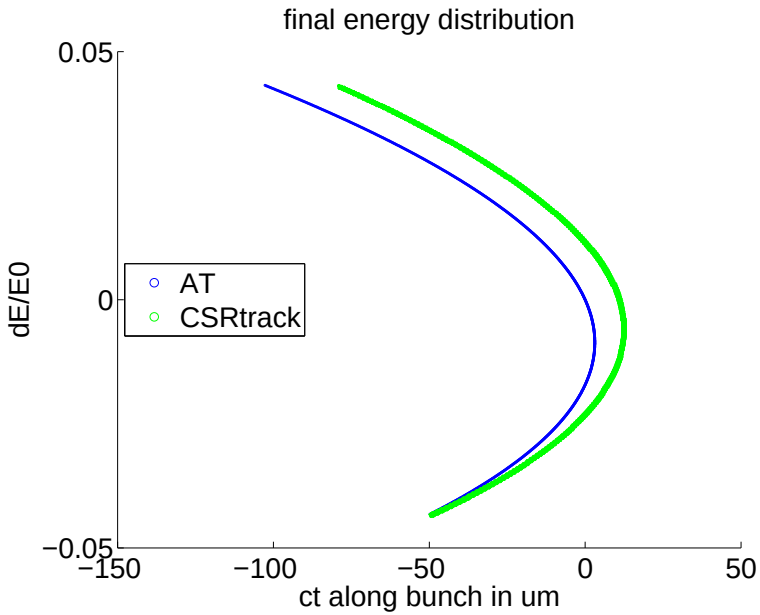
- $\pm 1 \cdot 10^{-13}\,\mathrm{s}$ for $E = E_0 \pm 0.1\%$
- $\pm 1 \cdot 10^{-12}\,\mathrm{s}$ for $E = E_0 \pm 1.0\%$

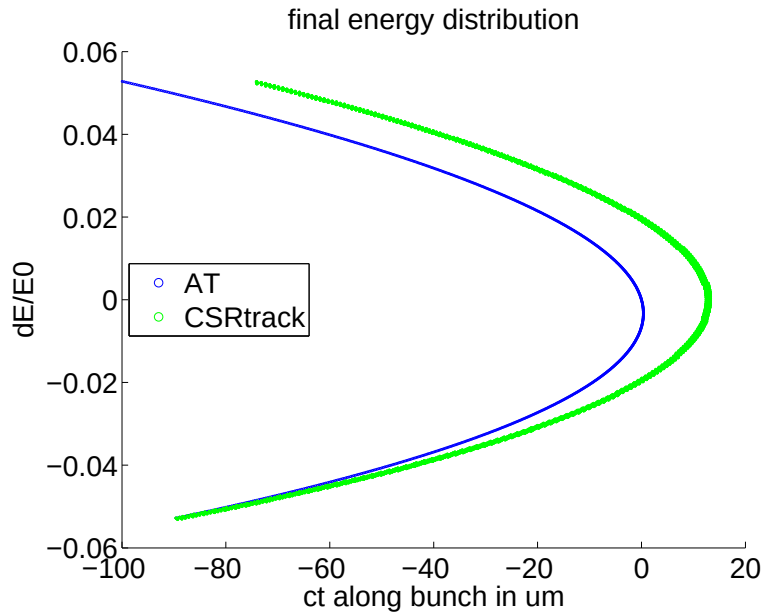
Times to compare:

- $1 \cdot 10^{-7}\,\mathrm{s}$ from bunch to bunch
- $5 \cdot 10^{-15}\,\mathrm{s}$ RMS peak width of electron bunch

Comparison with AT

For comparison some simulations were rerun with
the Accelerator Toolbox for Matlab:
(The examples below show two different energy distributions.)





- The results are slightly diffrent but show resonable agreement.
- This is to be expected since the two codes
  take other effects into account.

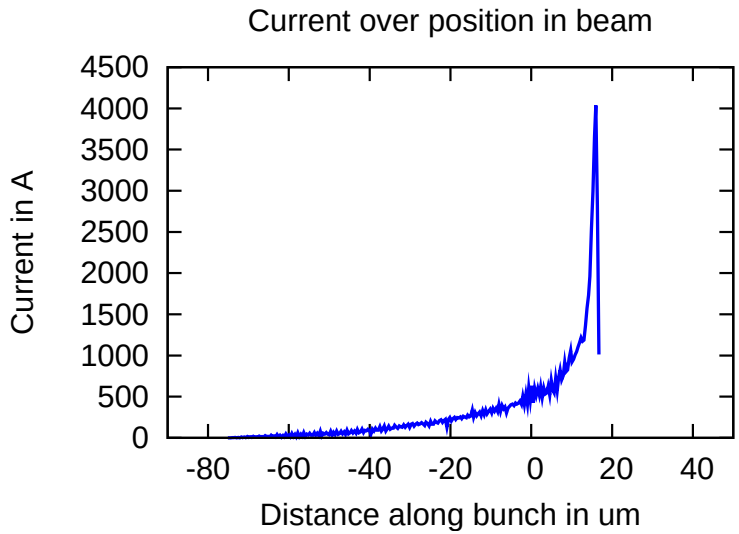
Summary

TBONE will produce

- instantanious broadband THz radiation,
- ulta-short pulses.

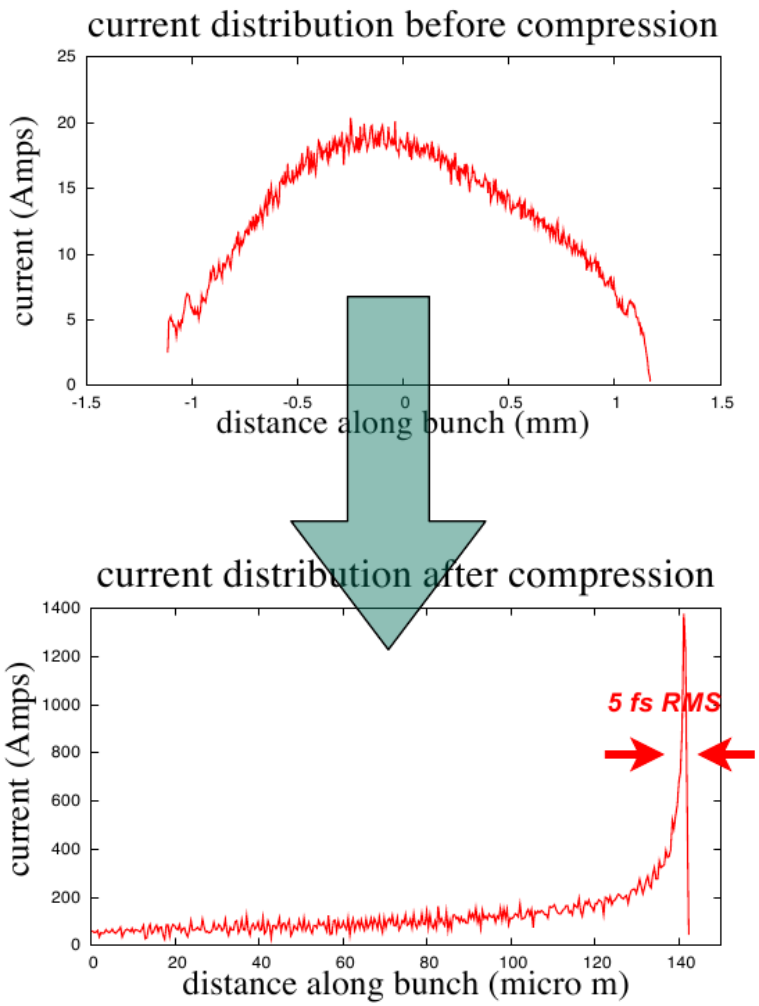
The simulations

- indicate that it is feasible to build such a machine,
- are not complete yet.



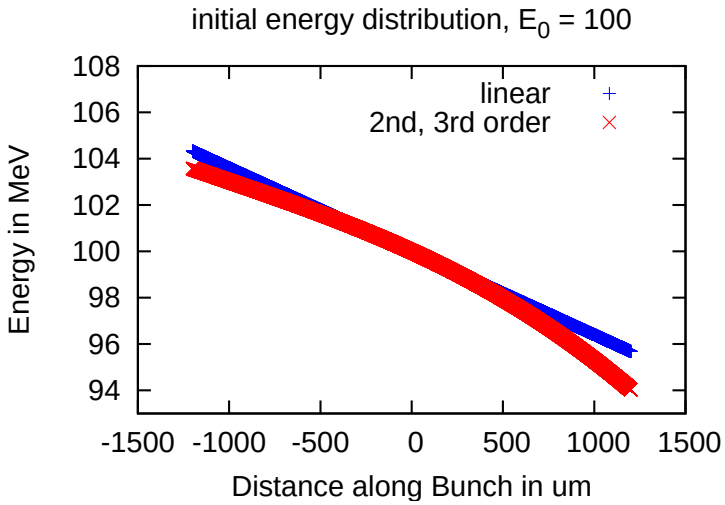
- Thank you! -

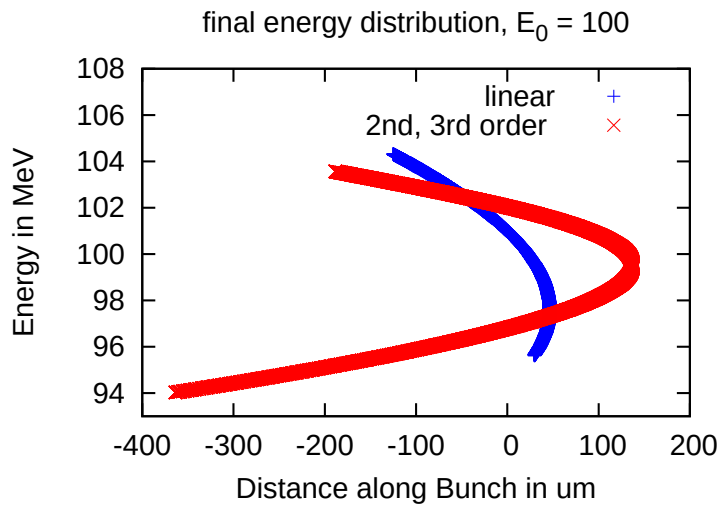
More Realistic Current Profile

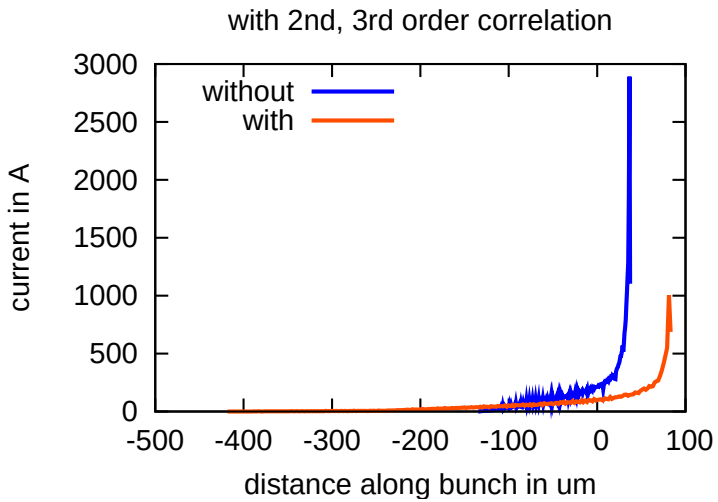


- simulation run with modified dataset (ideal case: parabolic shape)
- peak current is lower than in idealised case
- desired bunch length is still achieved

2nd and 3rd order E-z-Correlation







- peak current goes down
- desired compression is still achieved
- the long tail in the current distribution doesn't influence the THz production