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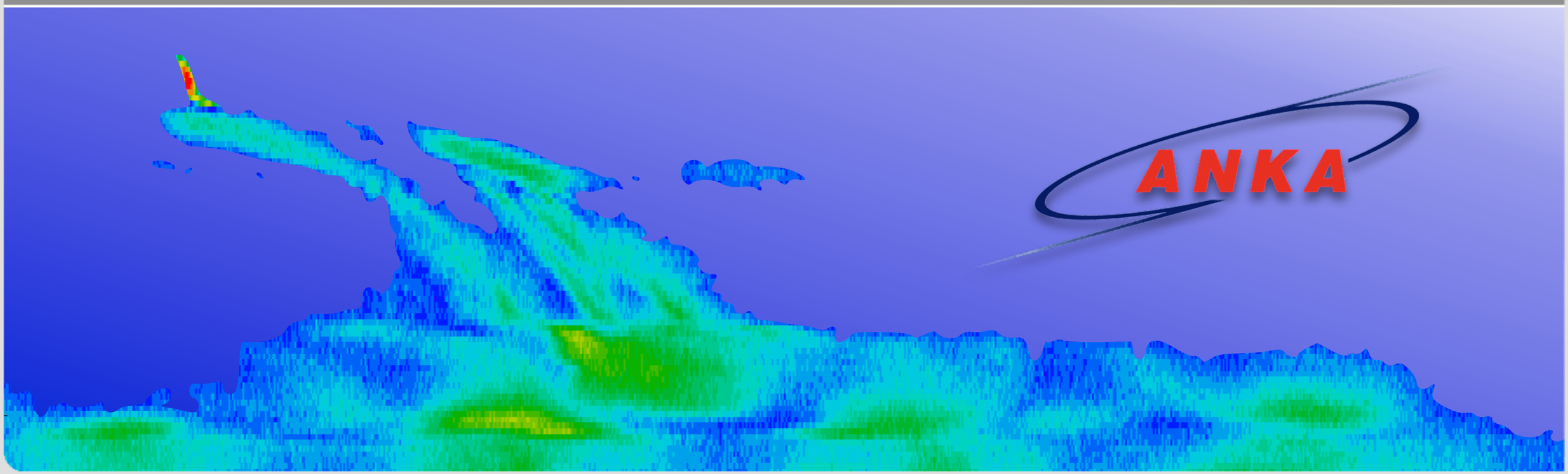
Experiments with short bunches at ANKA

M. Schwarz for the ANKA THz team
ANKA, Laboratory for Applications of Synchrotron Radiation

ANKA Synchrotron Light Source at **KIT**



Acknowledgements

- ANKA THz team
  A.-S. Müller,
  A. Borysenko,
  M. Brosi,
  N. Hiller,
  V. Judin,
  B. Kehrer,
  E. Hertle,
  M. J. Nasse,
  P. Schönfeldt,
  M. Schuh,
  J. Steinmann,
  J. Schwarzkopf,
  and the rest of the team...

- Colleagues at KIT
  M. Balzer,
  M. Caselle,
  M. Hofherr,
  E. Huttel,
  K.S. Ilin,
  J. Raasch,
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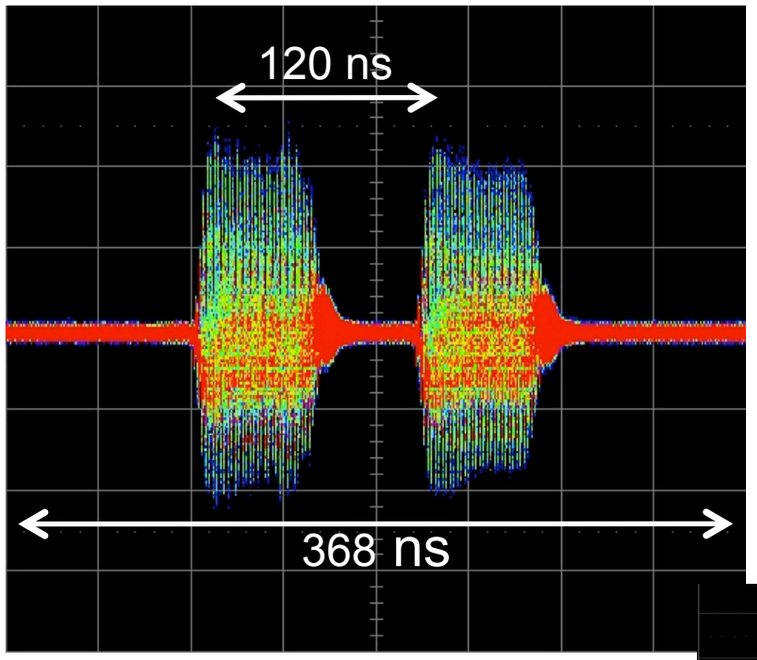
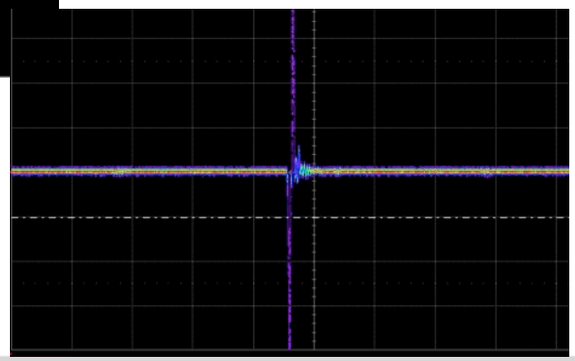
  M. Siegel,
  N.J. Smale,
  P. Thoma,
  M. Weber,
  S. Wuensch

The ANKA synchrotron radiation facility

- C = 110.4 m
- Energy range: 0.5 - 2.5 GeV
- RF frequency 500 MHz
- 368 ns revolution time





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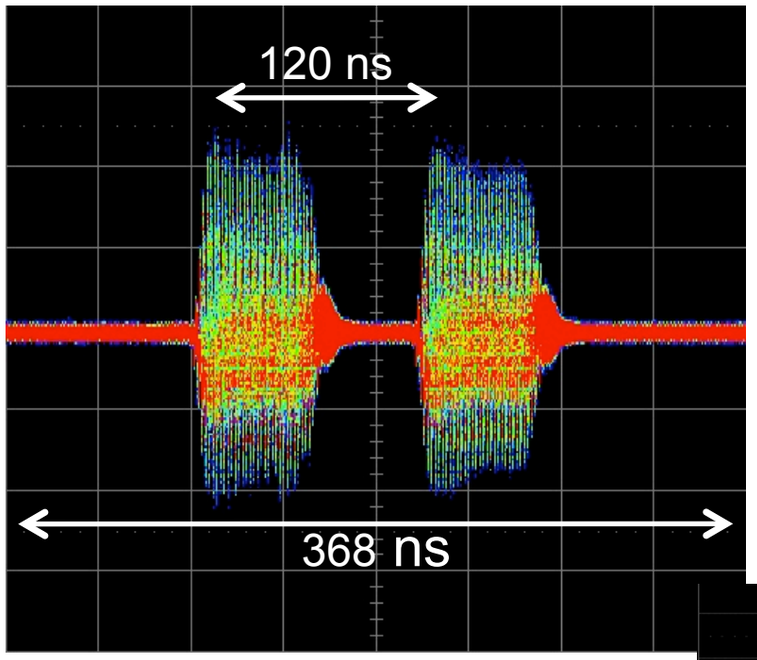
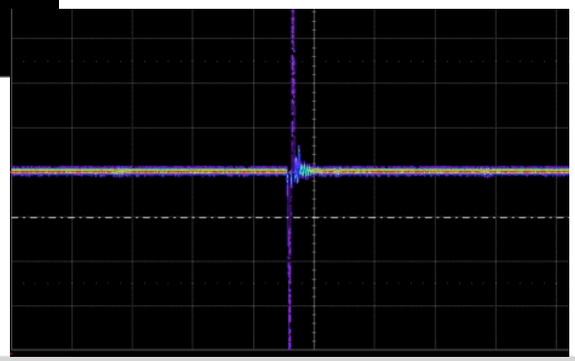
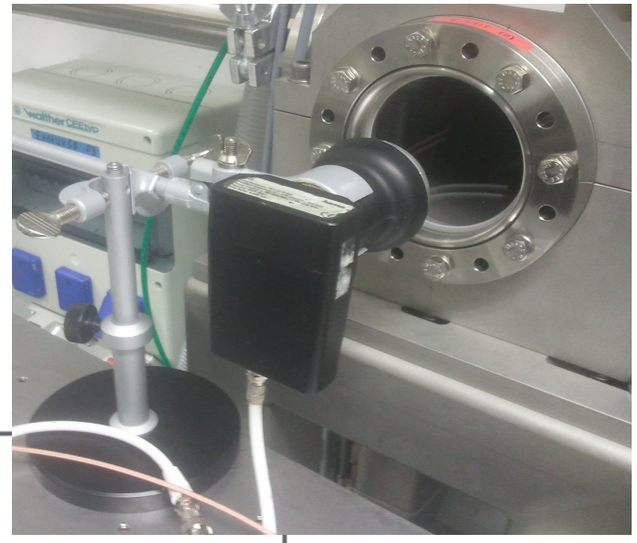
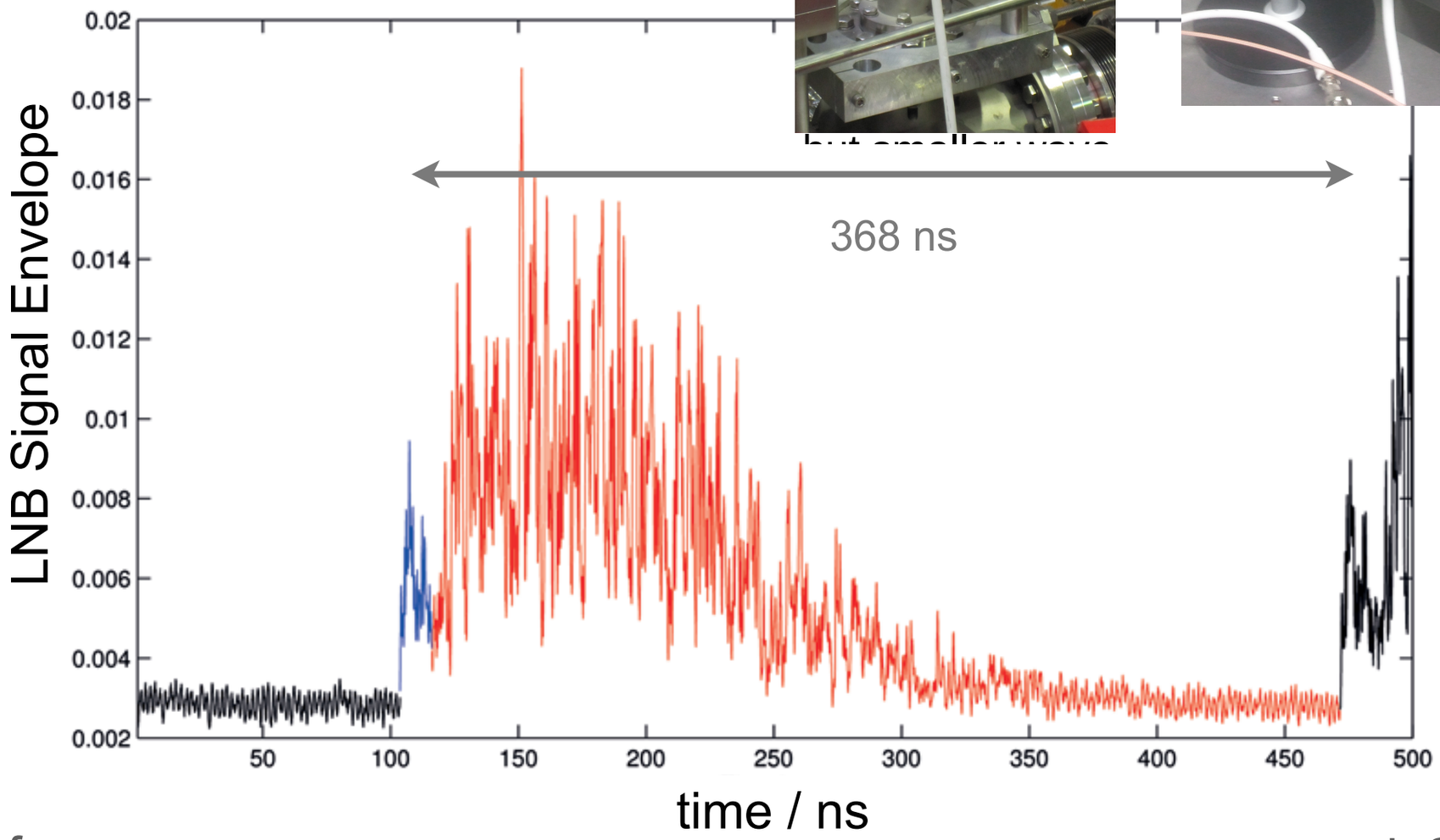




LNB / microwave detector studies

- LNB detector system (11 - 13 GHz)
- Single bunch response



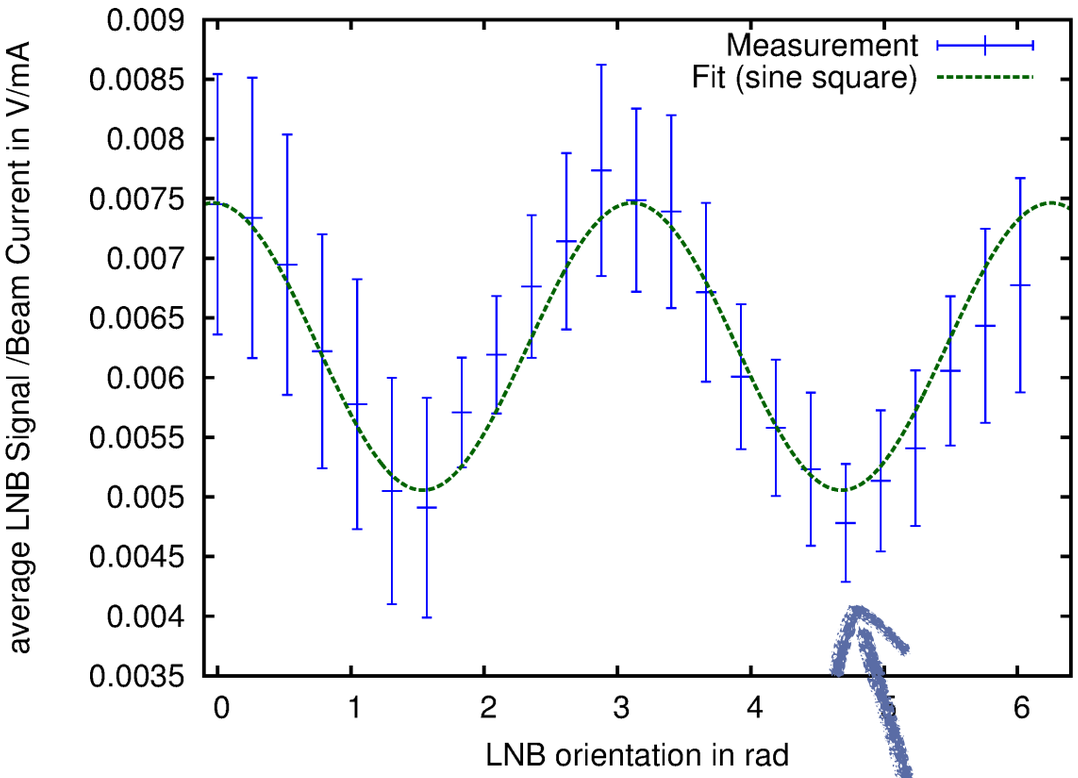


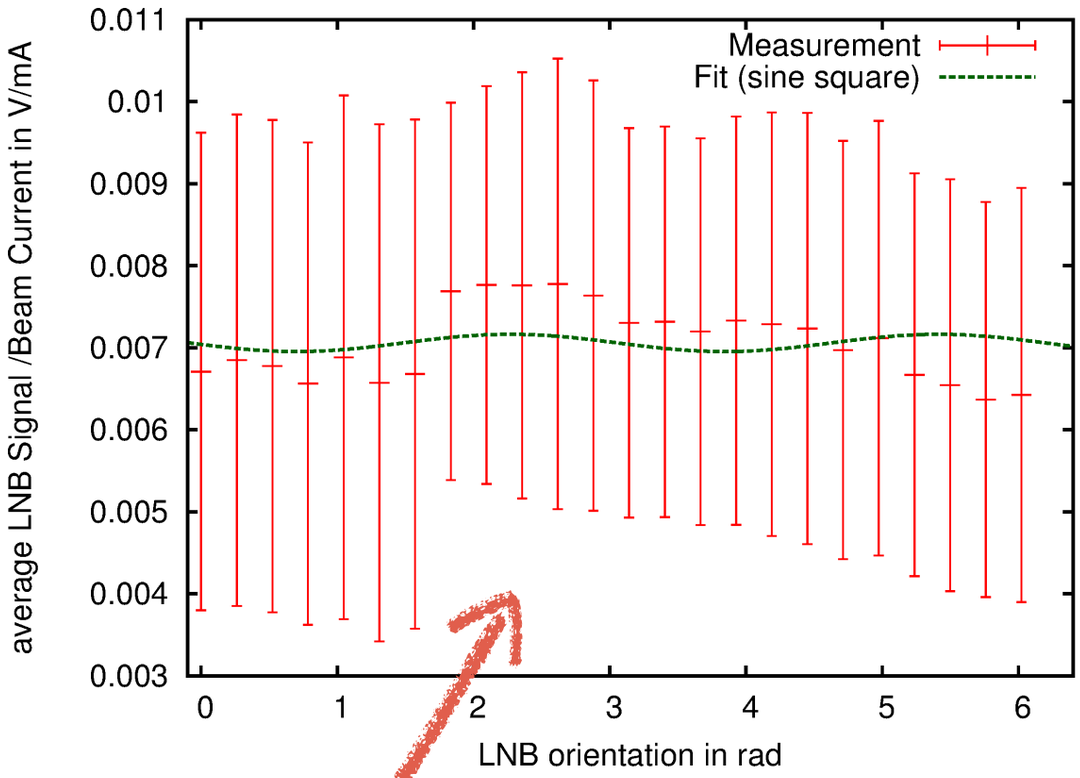
J. Schwarzkopf

J. Schwarzkopf

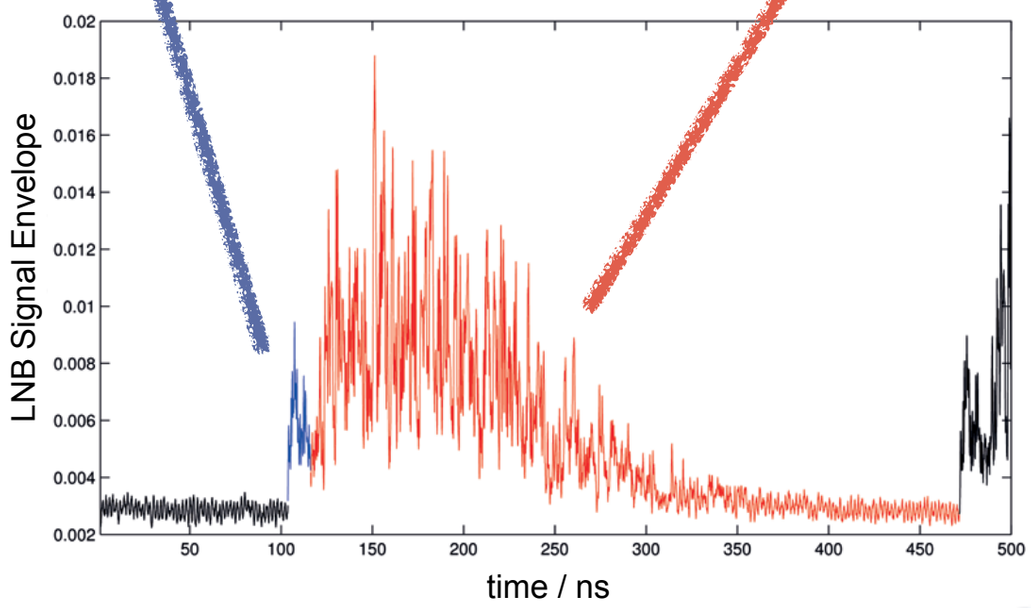
LNB / microwave detector studies

- LNB detector system (11 - 13 GHz)



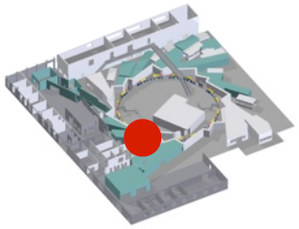


- First ~10 ns polarised



J. Schwarzkopf

Bursting CSR - single bunch observations



- Systematic survey of CSR instability vs. machine parameters

YBCO superconducting detector

P. Thoma et al., Appl. Phys. Lett. 101 (2012) 142601

NbN hot electron bolometer

A. D. Semenov et al., IRMMW-THz 2009

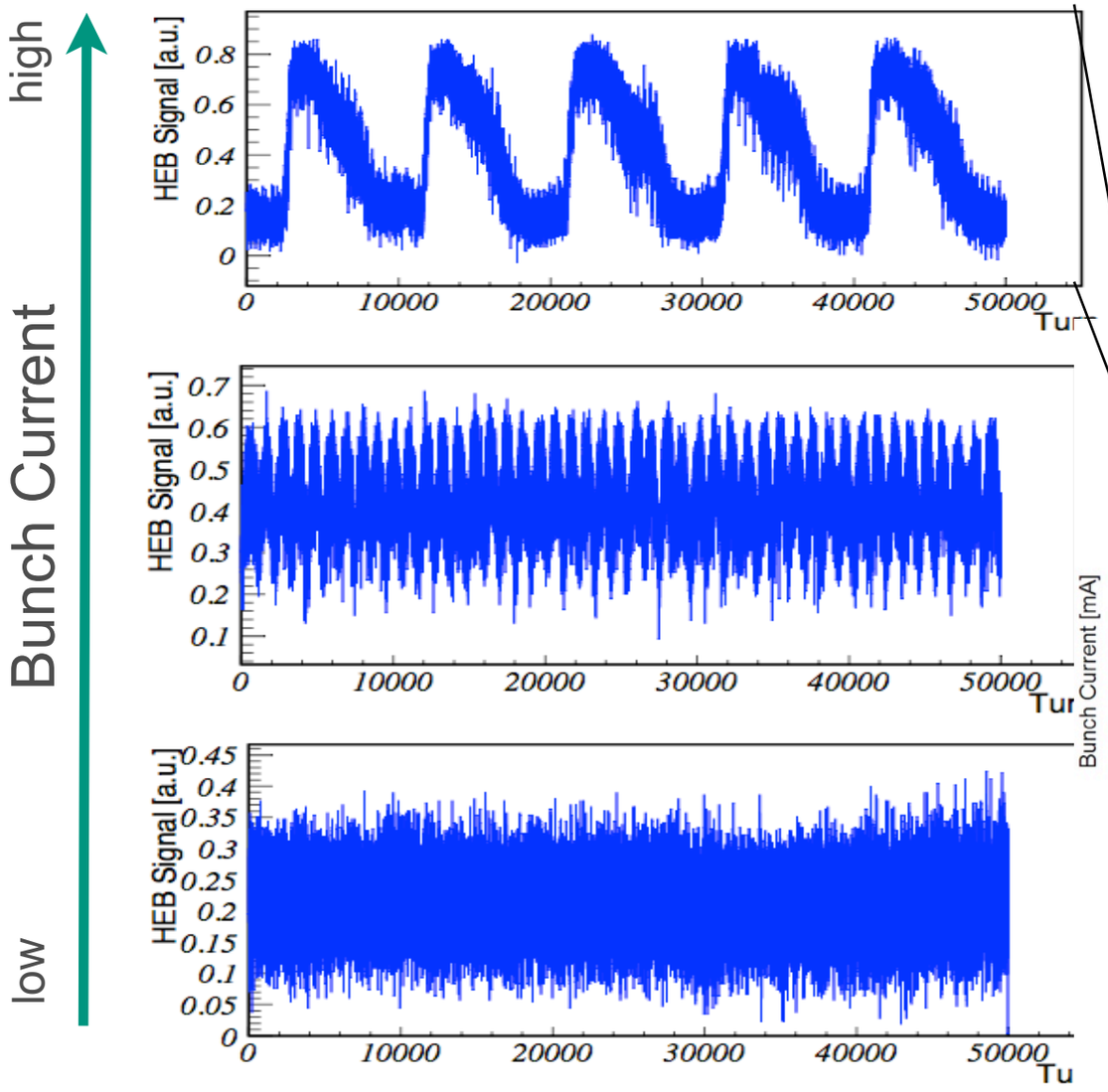
Advanced Compound Semiconductor Technologies GmbH

Schottky diode system

Bursting CSR - single bunch observations

- Dynamics of sub-structures lead to bursts of CSR

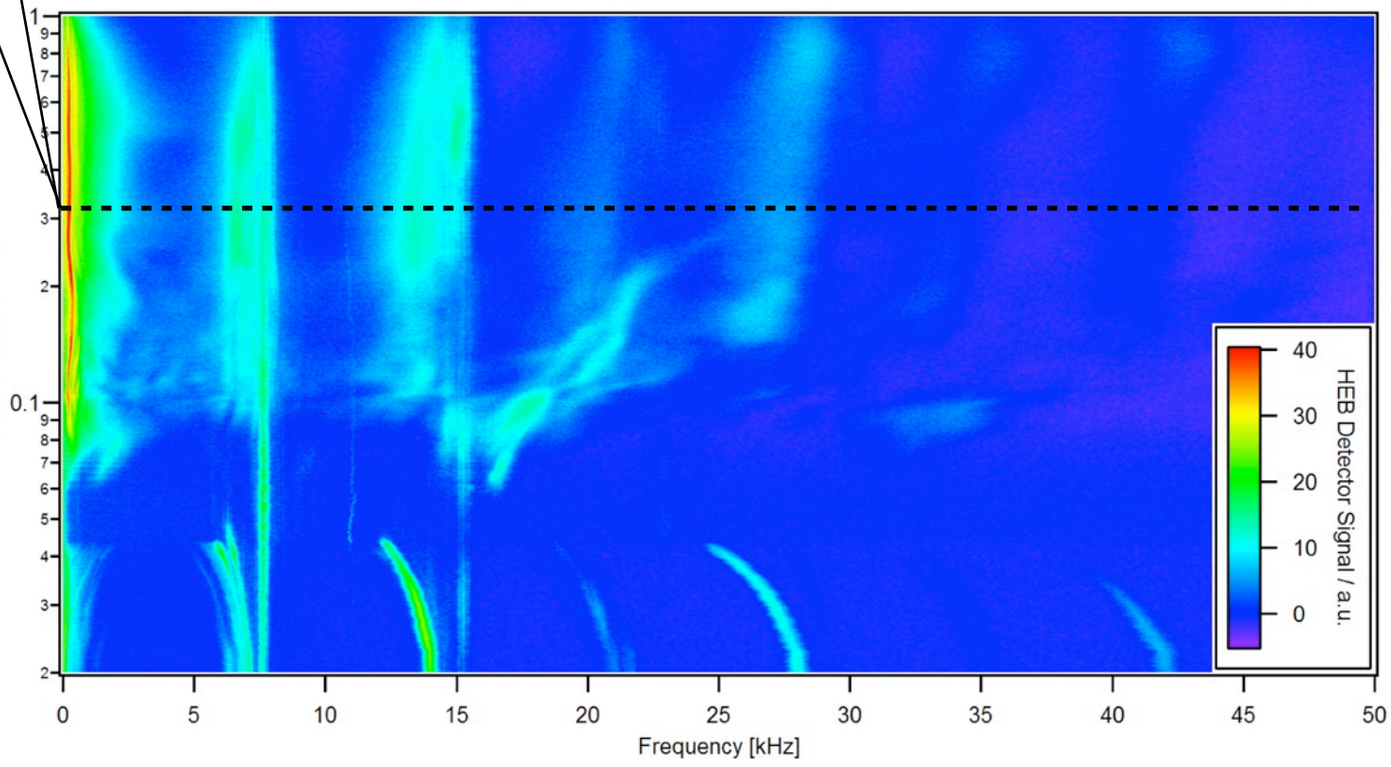
THz signal in the time domain
measured with HEB for different currents



V. Judin et al., IPAC'10, WEPEA021

FFT

THz signal in the time domain
for different currents yields
spectrogram.

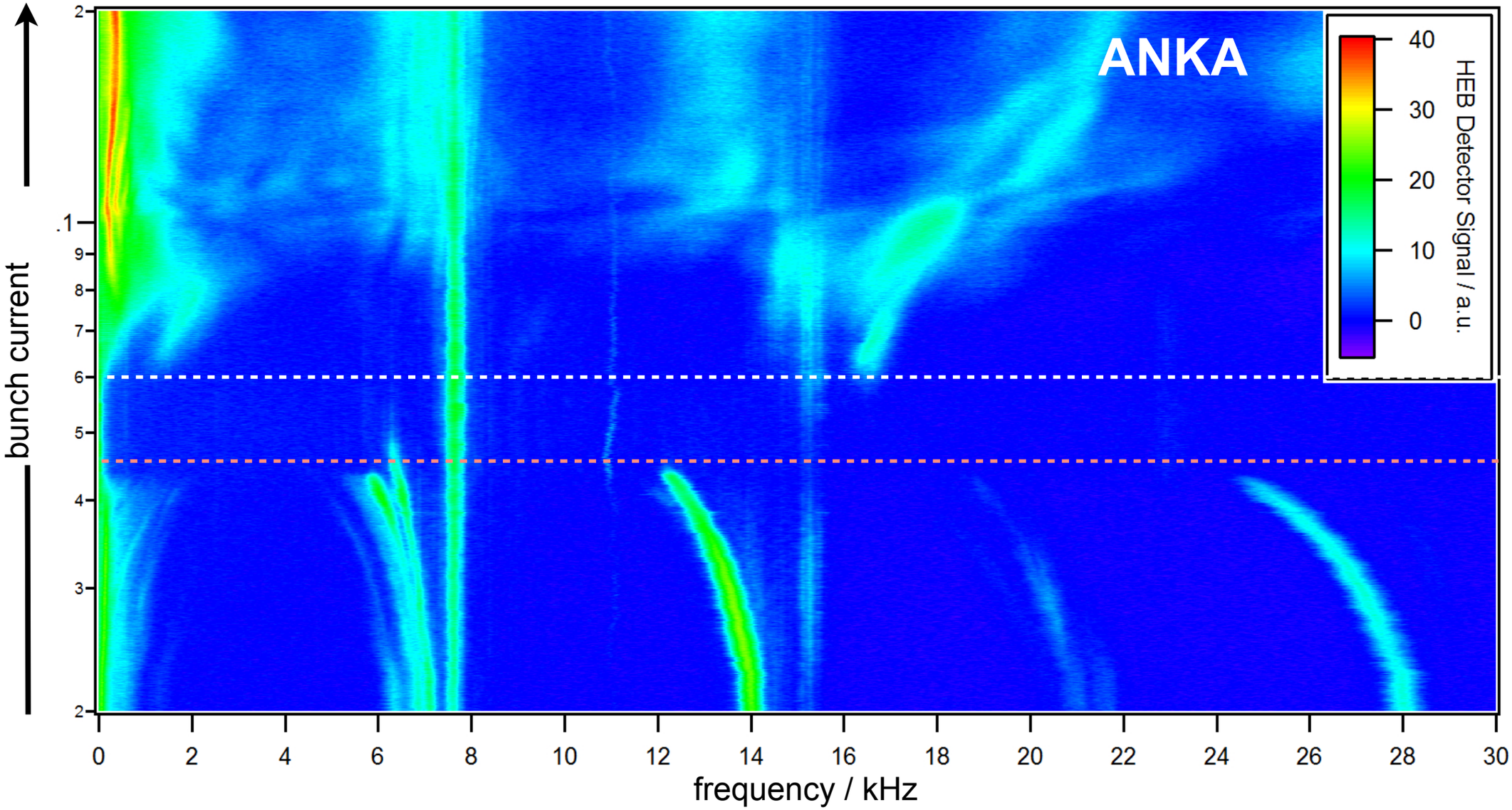


Frequency [kHz]

M. Brosi, V. Judin, J. Steinmann

Bursting CSR - single bunch observations

- Systematic survey of CSR instability vs. machine parameters

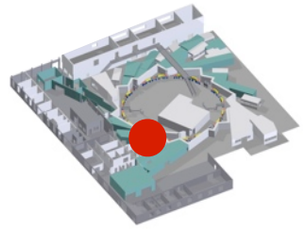


V. Judin et al., IPAC'13, WEPEA011
ASM et al., IPAC'13, MOPEA019

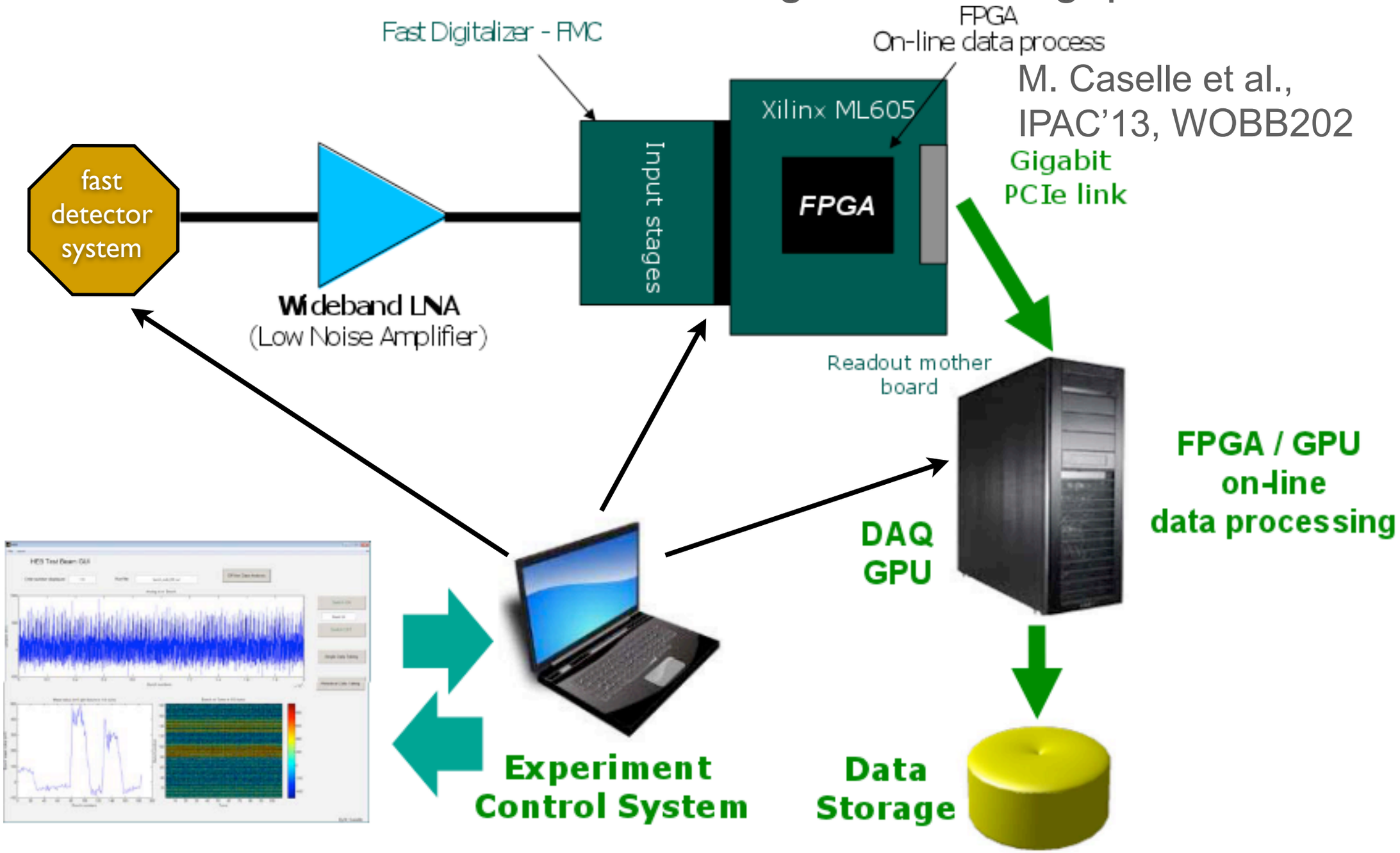
G. Stupakov et al. PRST-AB 5, 054402 (2002)

Y. Cai, IPAC'11, FRXAA01

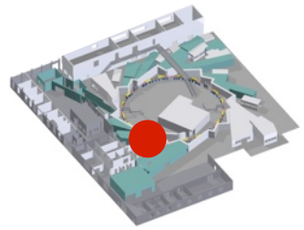
Bursting CSR - multi-bunch observations



- Combination of ultra-fast detectors & high data throughput readout



Bursting CSR - multi-bunch observations



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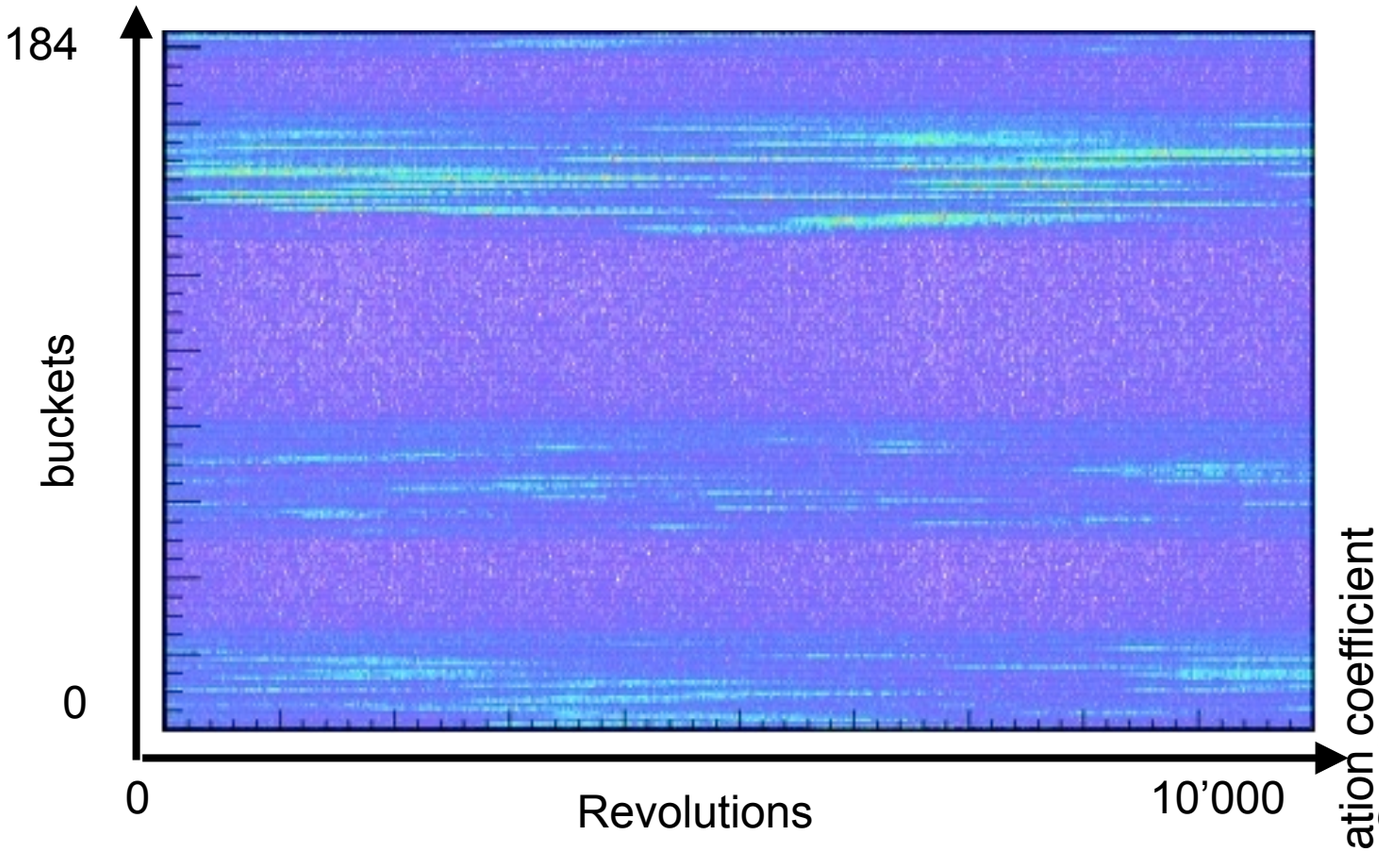
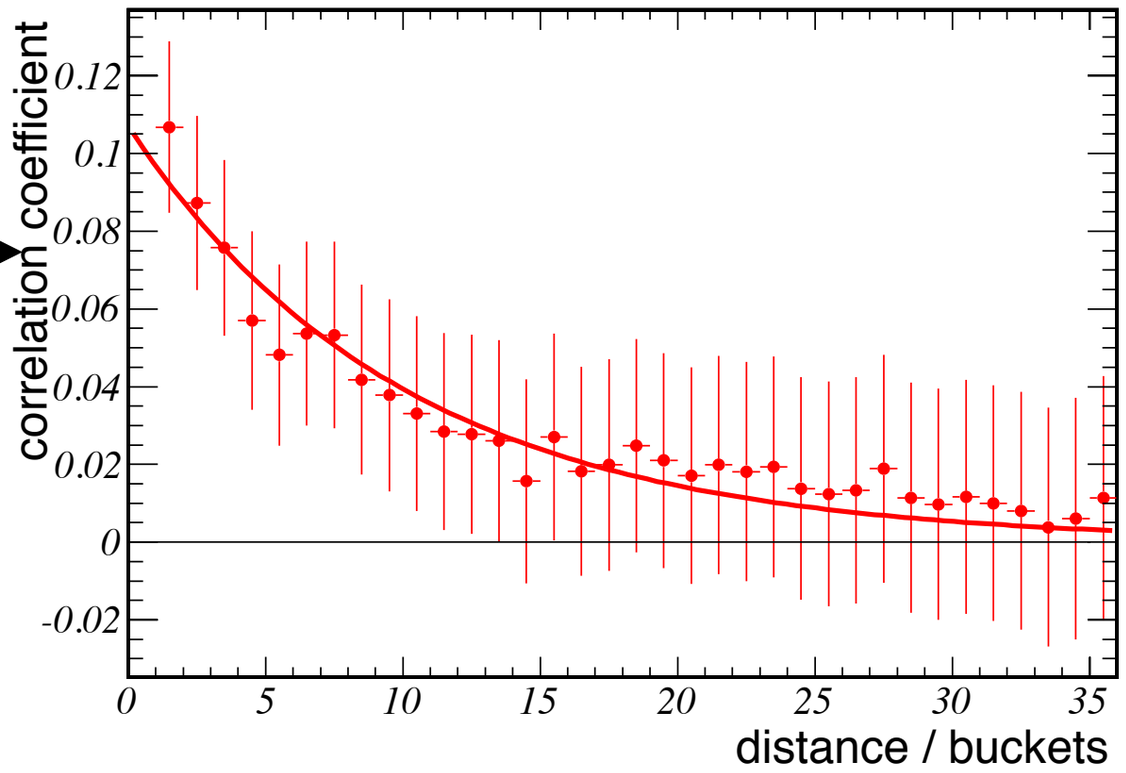


Ultra-fast simultaneous detection of THz signal from all bunches over many revolutions

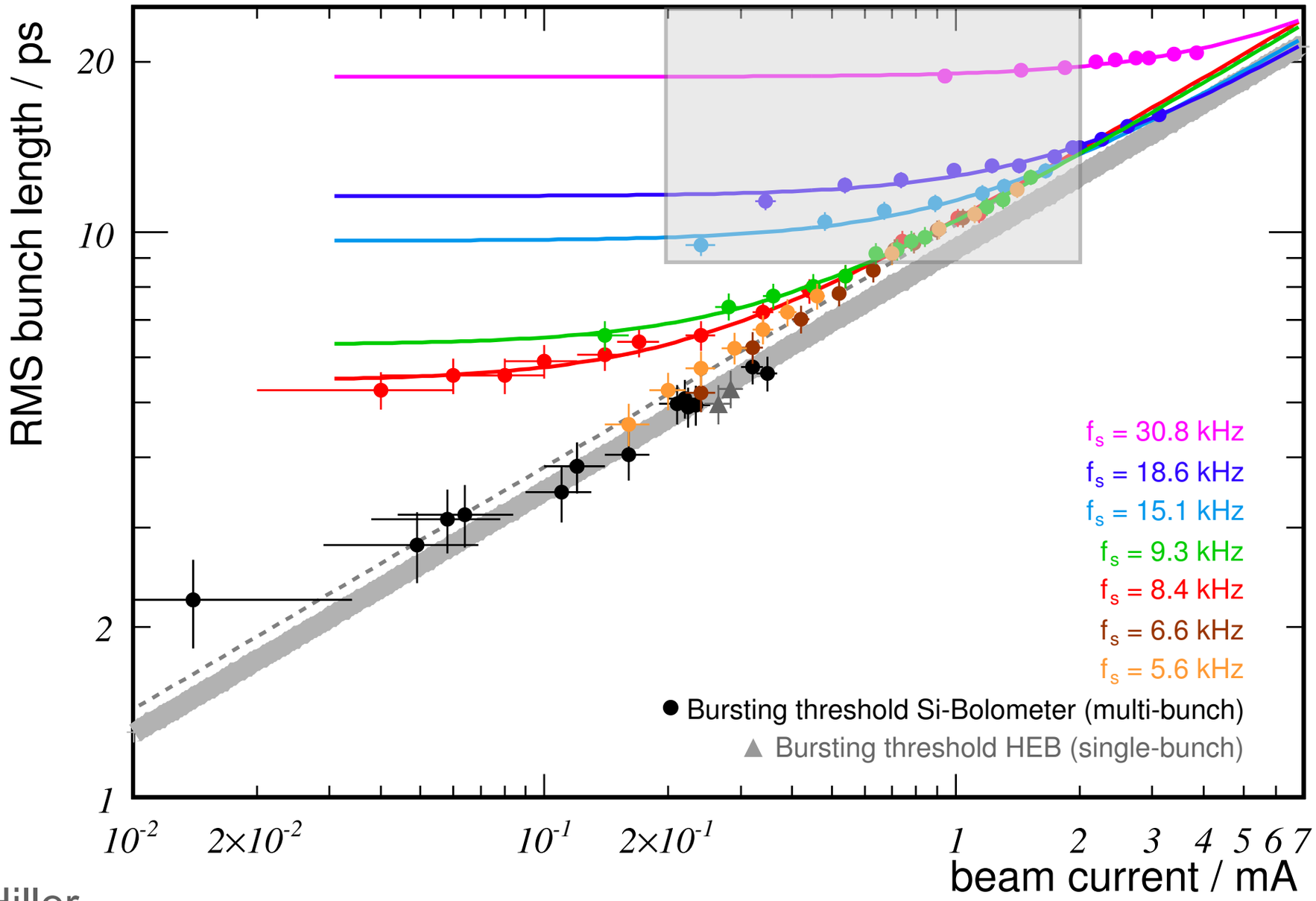
$$\rho(x,y) = \frac{\sum_{i=1}^{N}(x_i-\bar{x})(y_i-\bar{y})}{\sqrt{\sum_{i=1}^{N}(x_i-\bar{x})^2 \cdot \sum_{i=1}^{N}(y_i-\bar{y})^2}}$$



Correlation coefficients as a function of distance between buckets

Bunch length and CSR instability

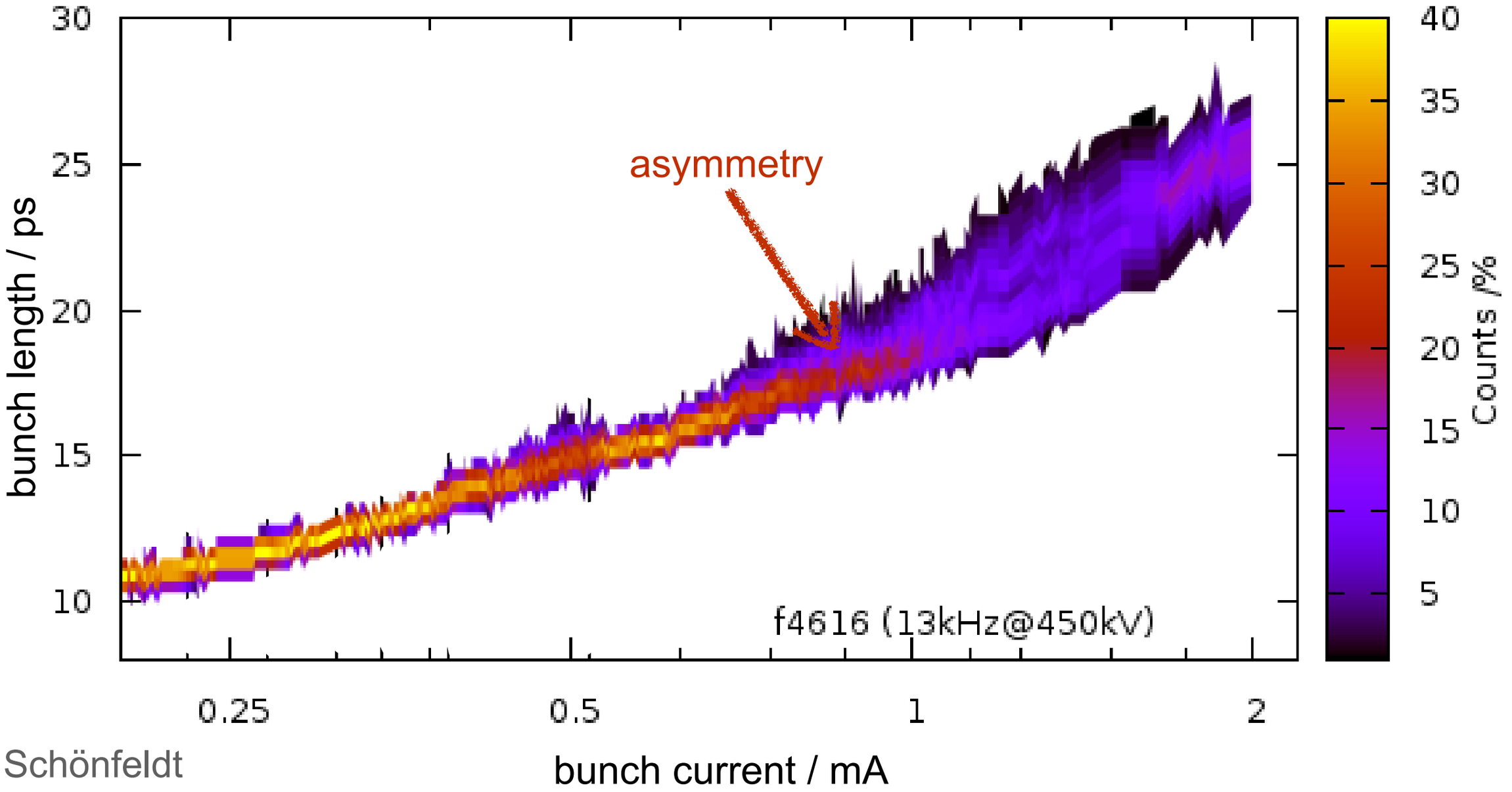
- Bunch length from streak camera for different α_c



N. Hiller

Bunch length and CSR instability

- Fluctuation of individual bunch length measurements



P. Schönfeldt

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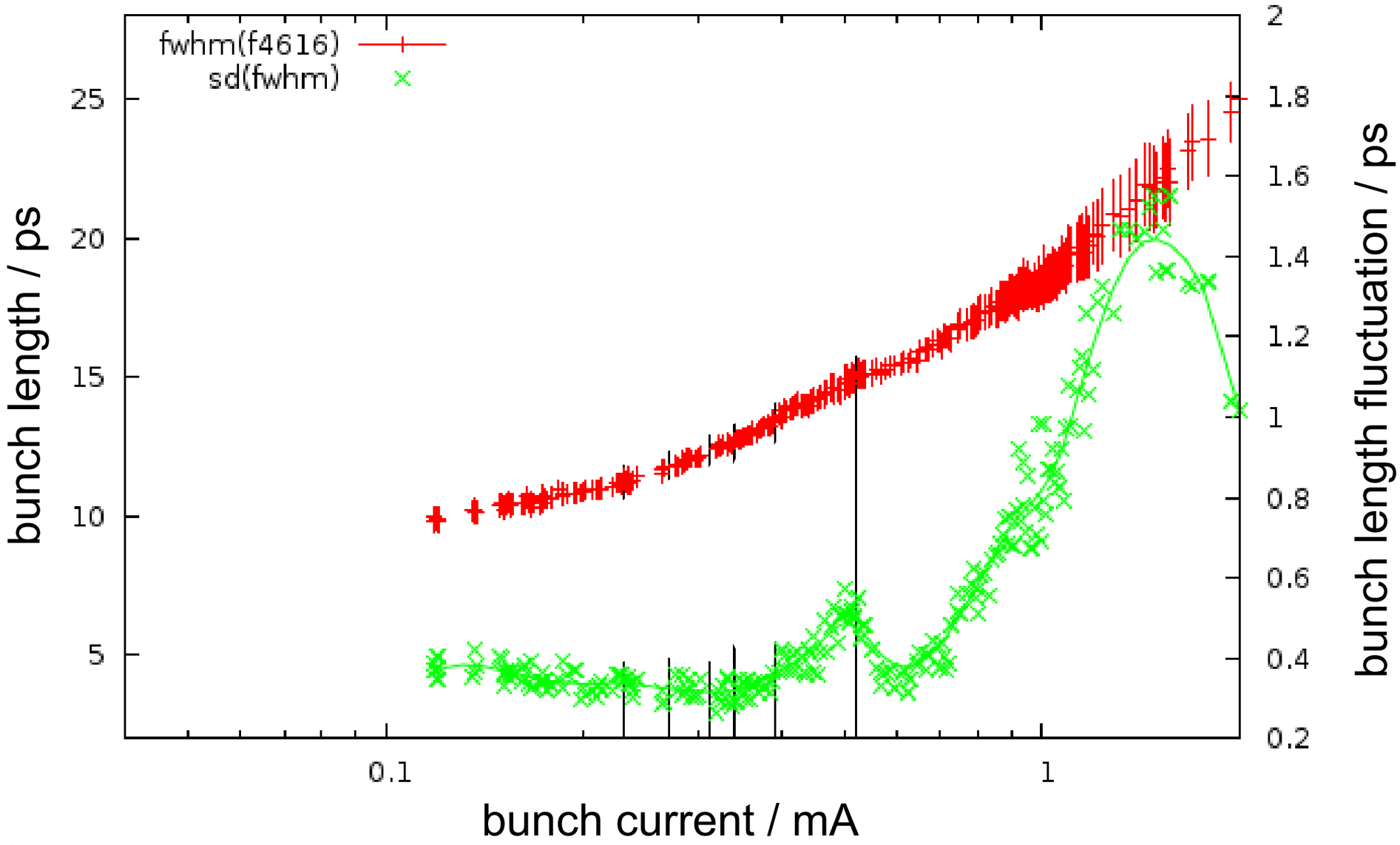

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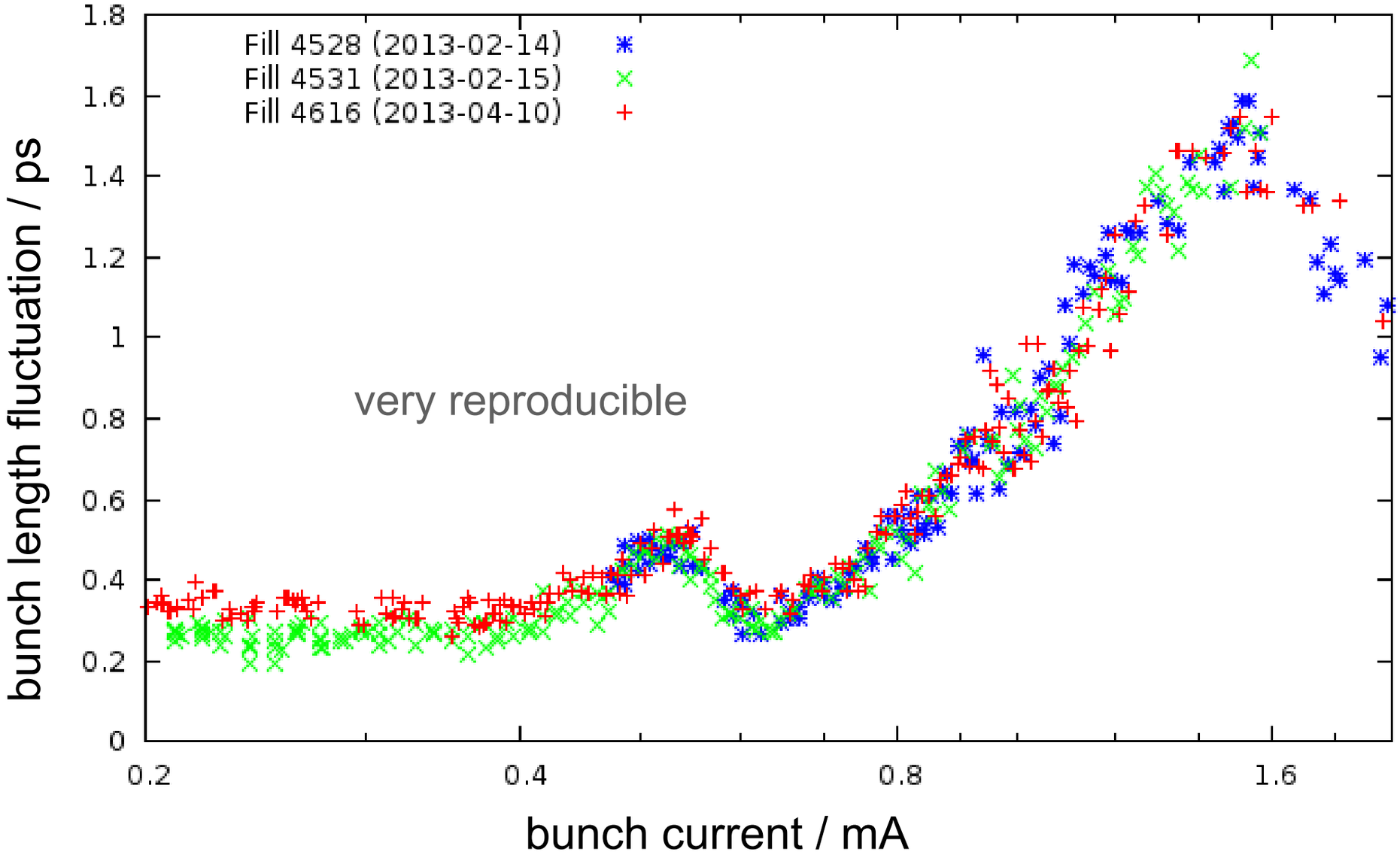
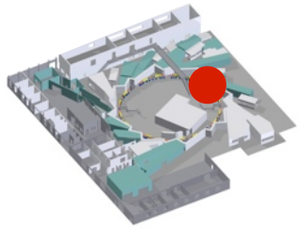


P. Schönfeldt

Direct detection of bunch fields



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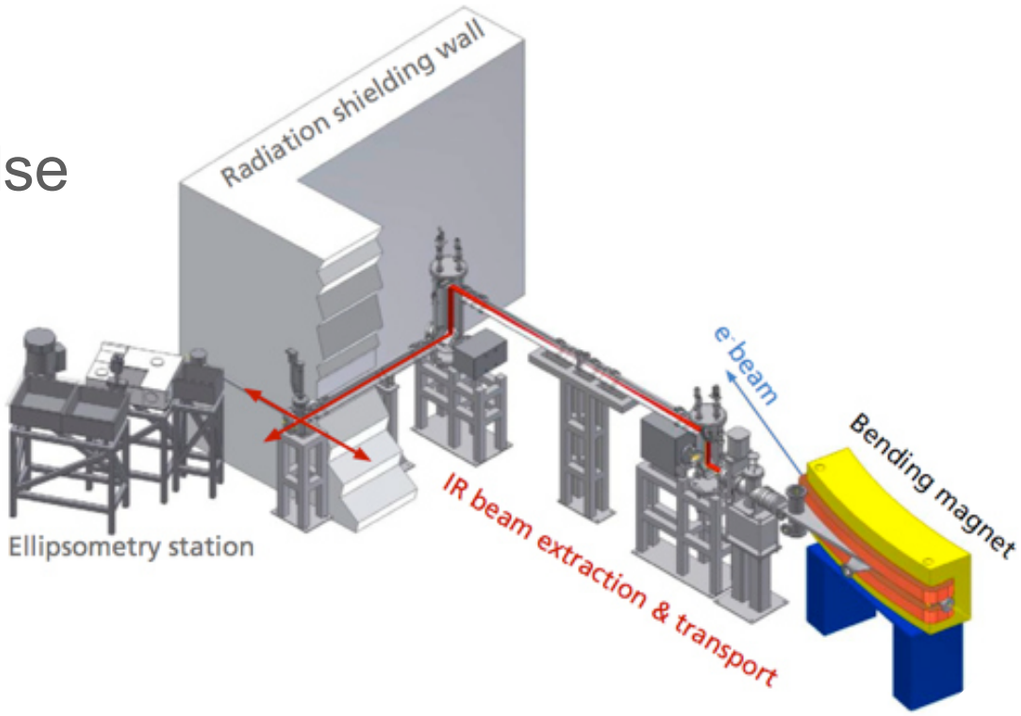
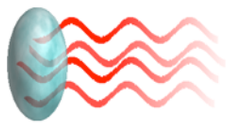
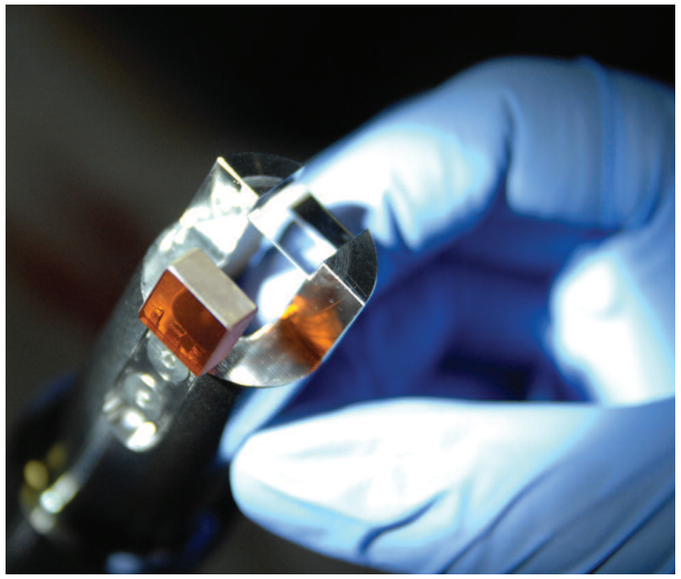
- Measurements in two basic set-ups
  - detection of synchrotron radiation THz pulse in the beam line (“far-field”)
  - (direct) detection of bunch electric field (“near-field”)



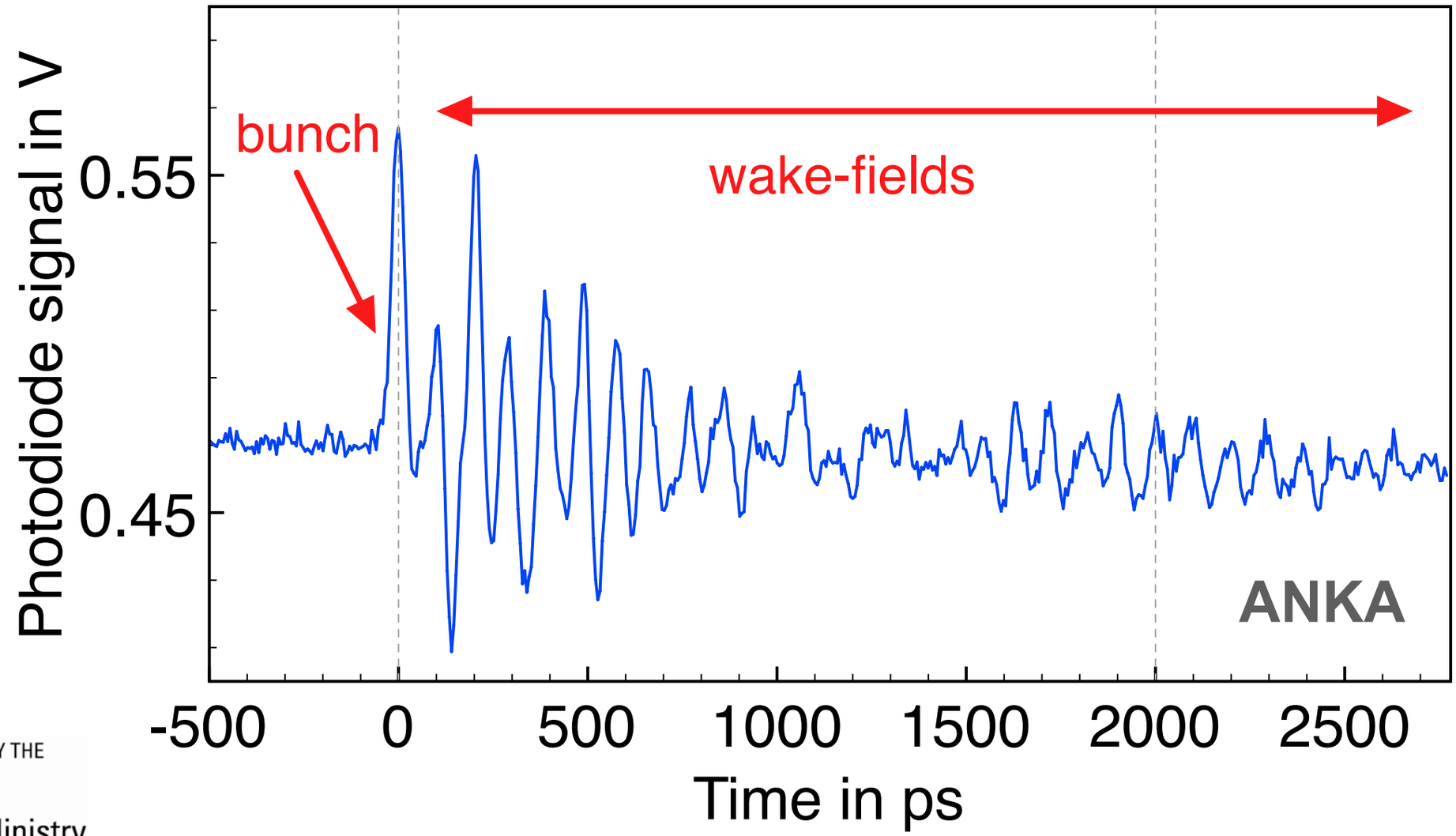


- Electro-optic (EO) methods measures
  - wake field (EO sampling)
  - bunch shape (EO spectral decoding, single shot!)



EO sampling: bunch & wake field

- EOS measurement of the E-field induced birefringence inside GaP crystal from passing bunch



N. Hiller et al., IPAC'13, MOPEA014
B. Kehrer et al., IPAC'13, MOPEA015

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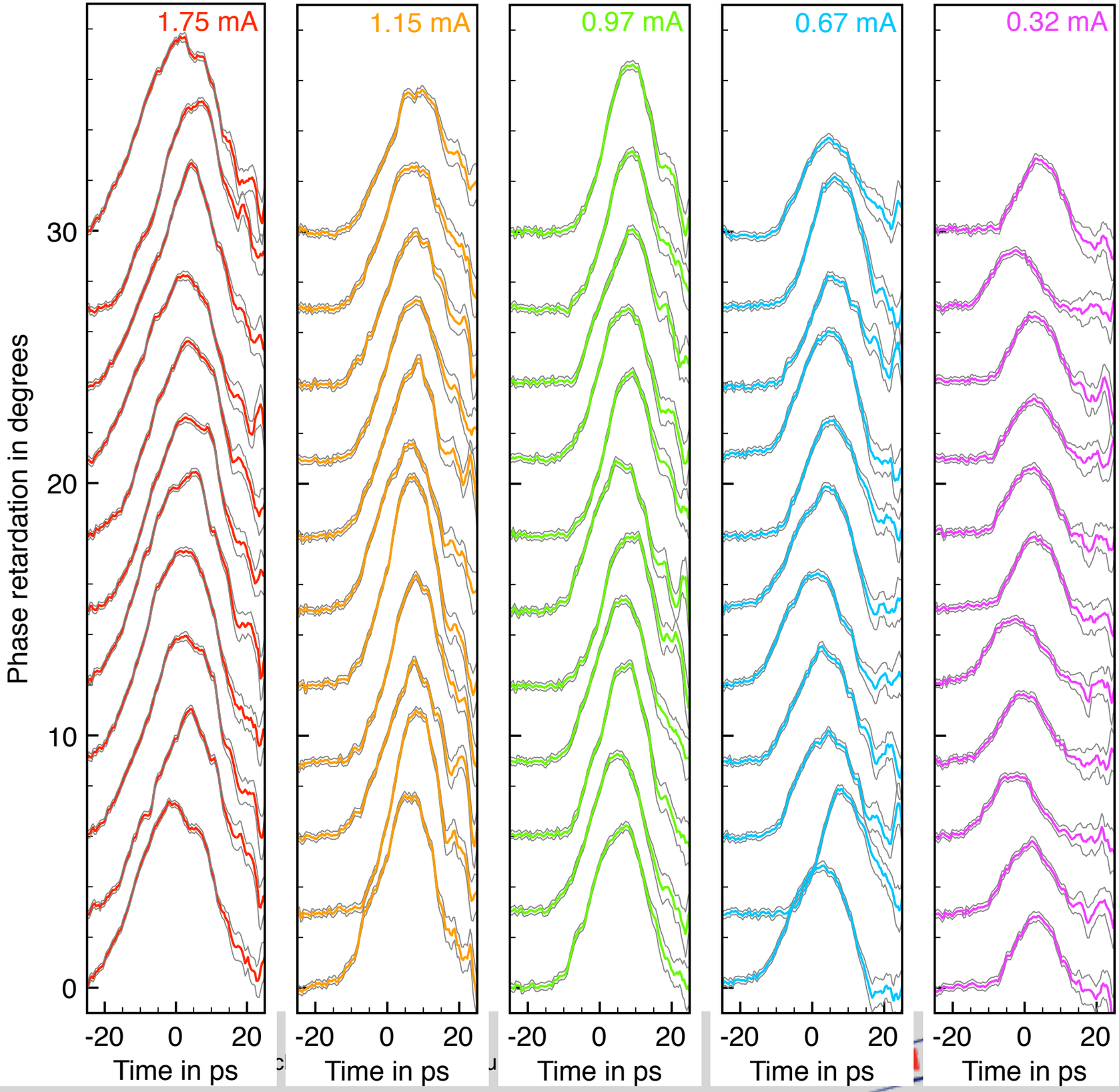
EO single shot profiles

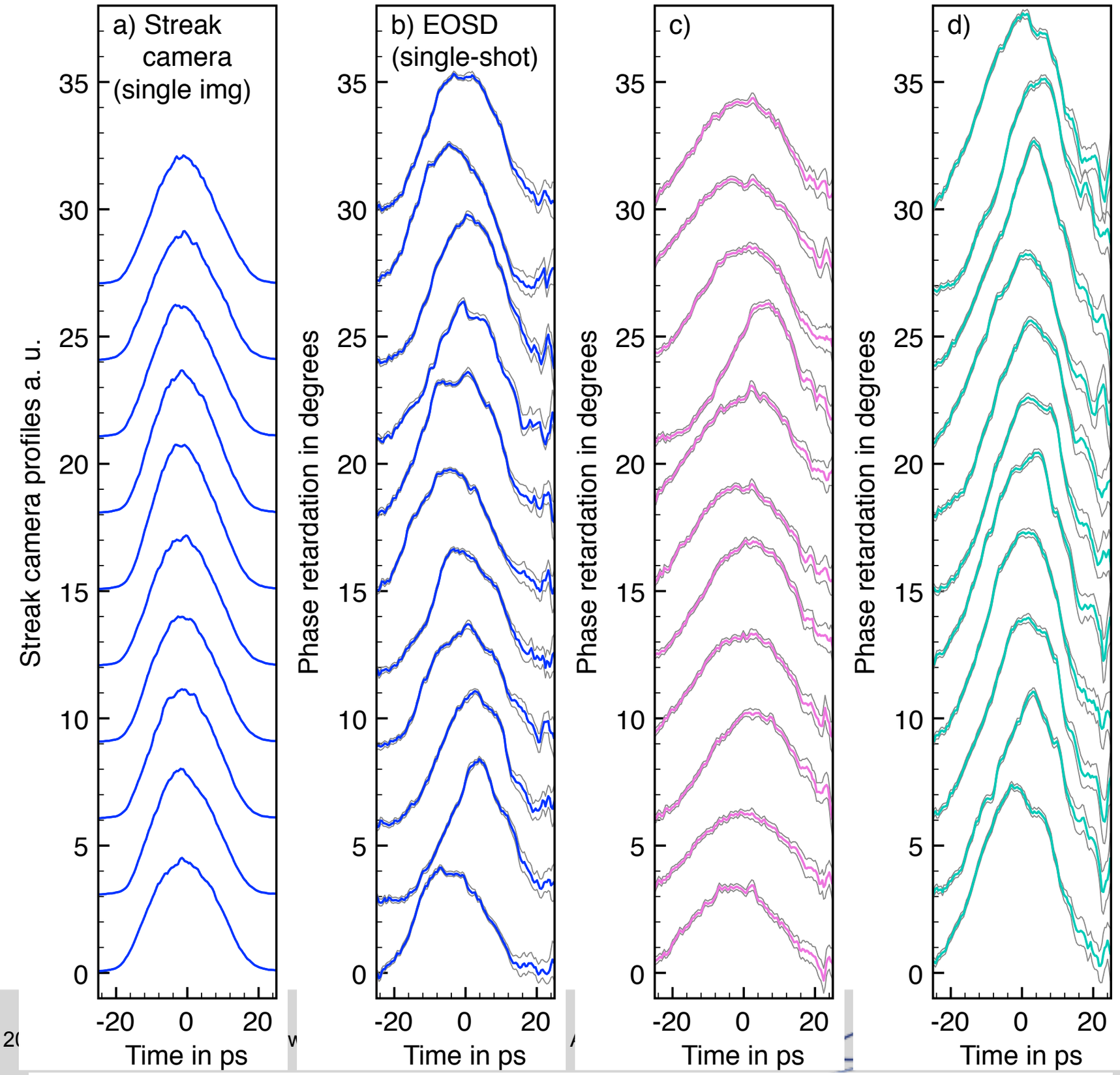


N. Hiller

Summary

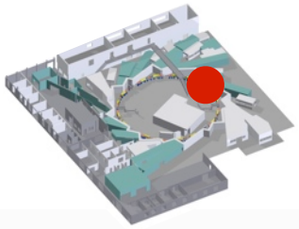
- Detector systems working in different frequency ranges are used for CSR studies around ANKA
  - ultimate goal: true simultaneous DAQ of all those systems
- Some results / effects under investigation:
  - LNB, multi-bunch studies & EO methods show evidence for long-range effects
  - bunch length during bursting mode changes
  - single shot bunch profiles of CSR instability
  - polarization of microwave signal
- CSR gives fingerprint of machine parameters
  - next steps: systematic parameter scans, detailed simulations

EO single shot profiles



N. Hiller

EO set-up in the ANKA vacuum chamber



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- Retractable arm with ‘slider’ as shielding for user operation
- EO monitor designed at PSI & DESY adapted for use with ANKA

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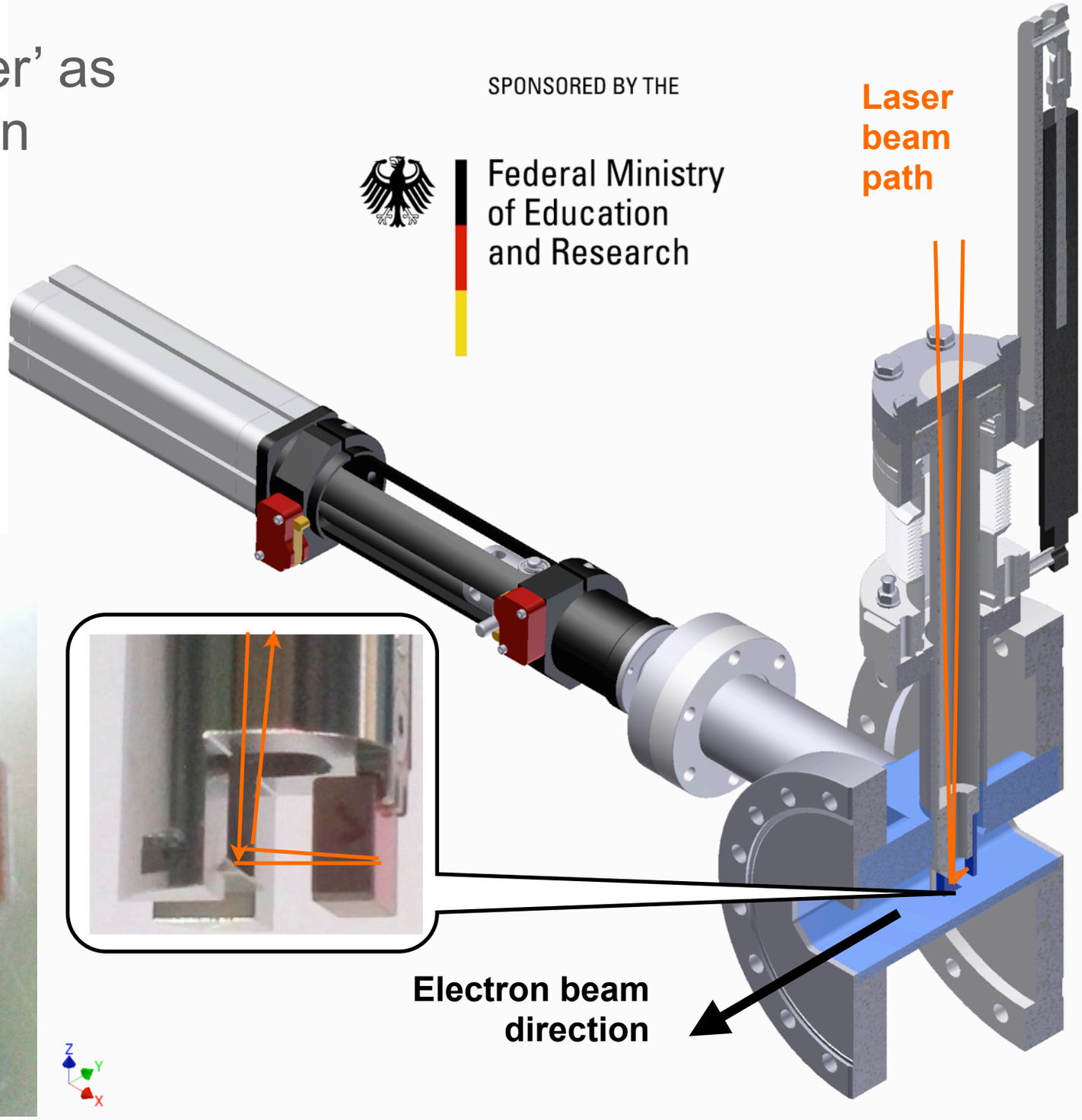
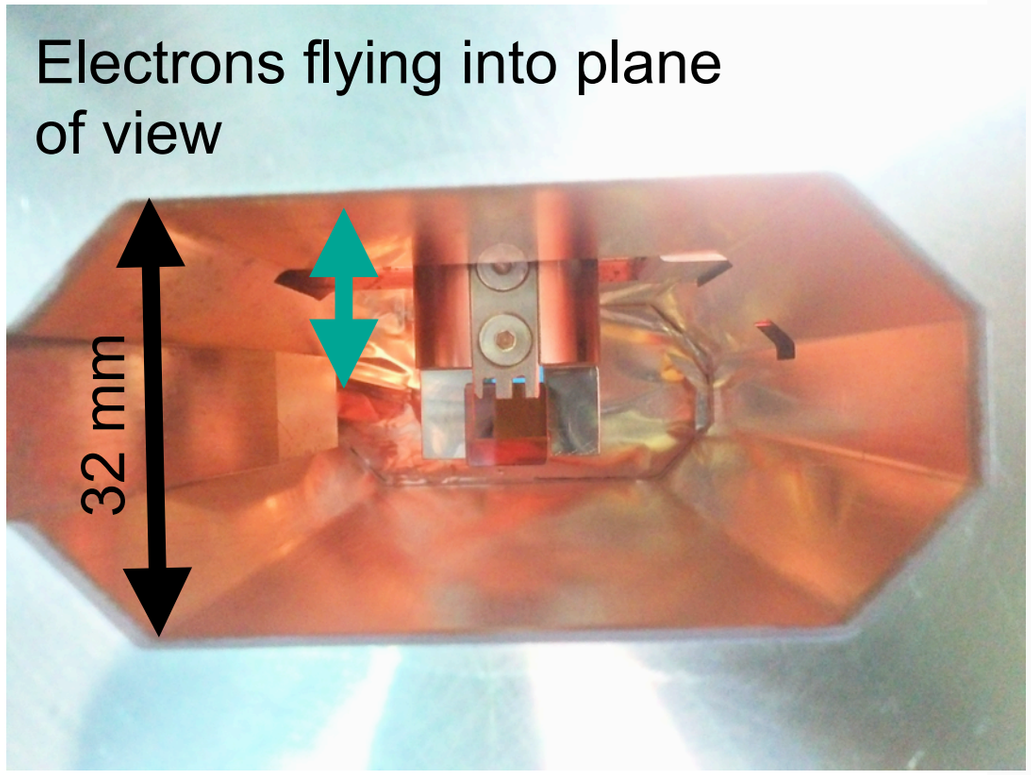
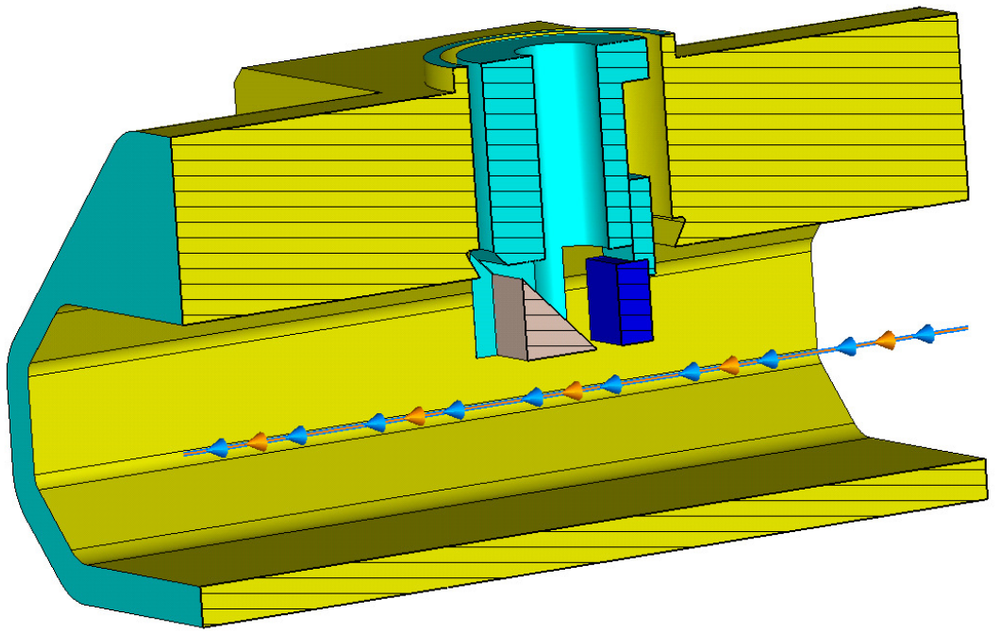
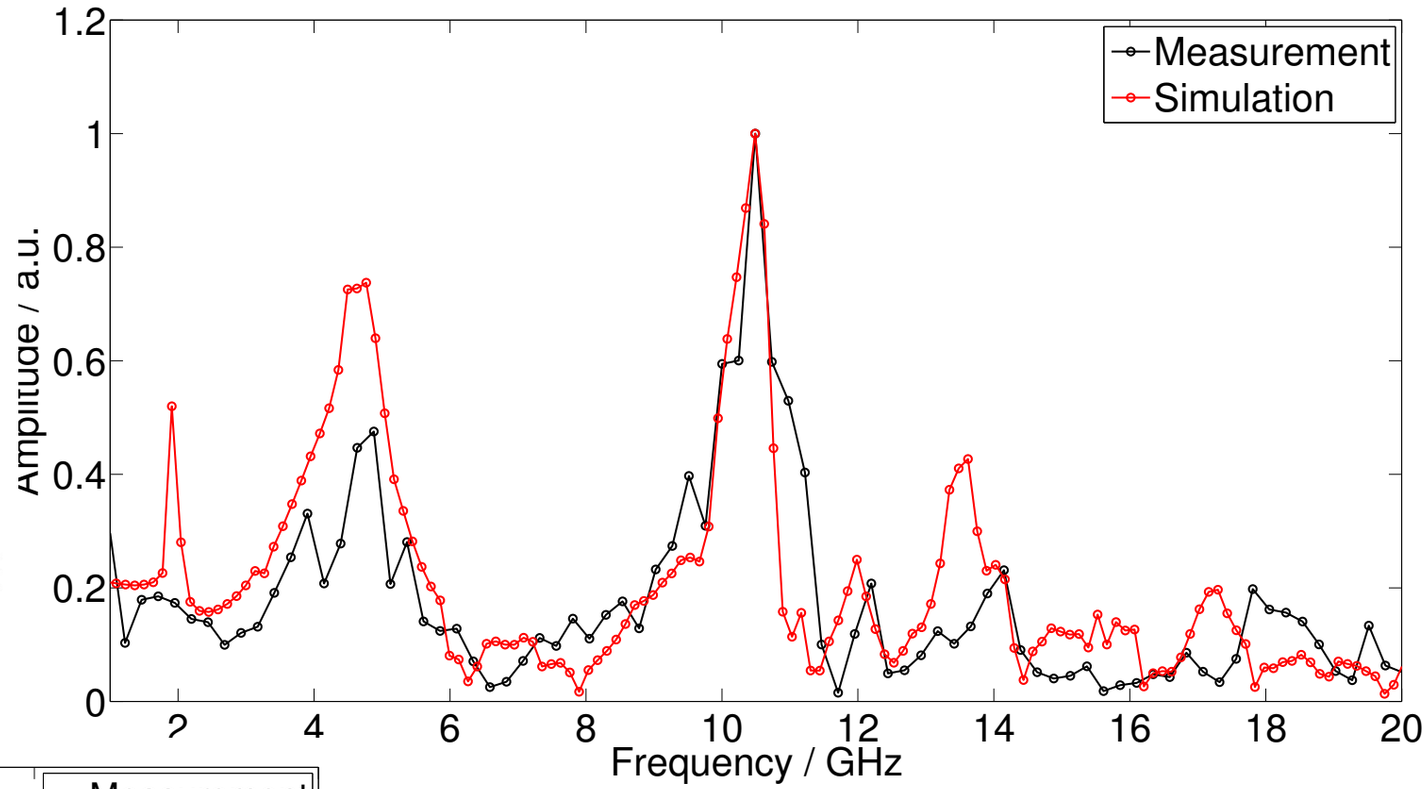
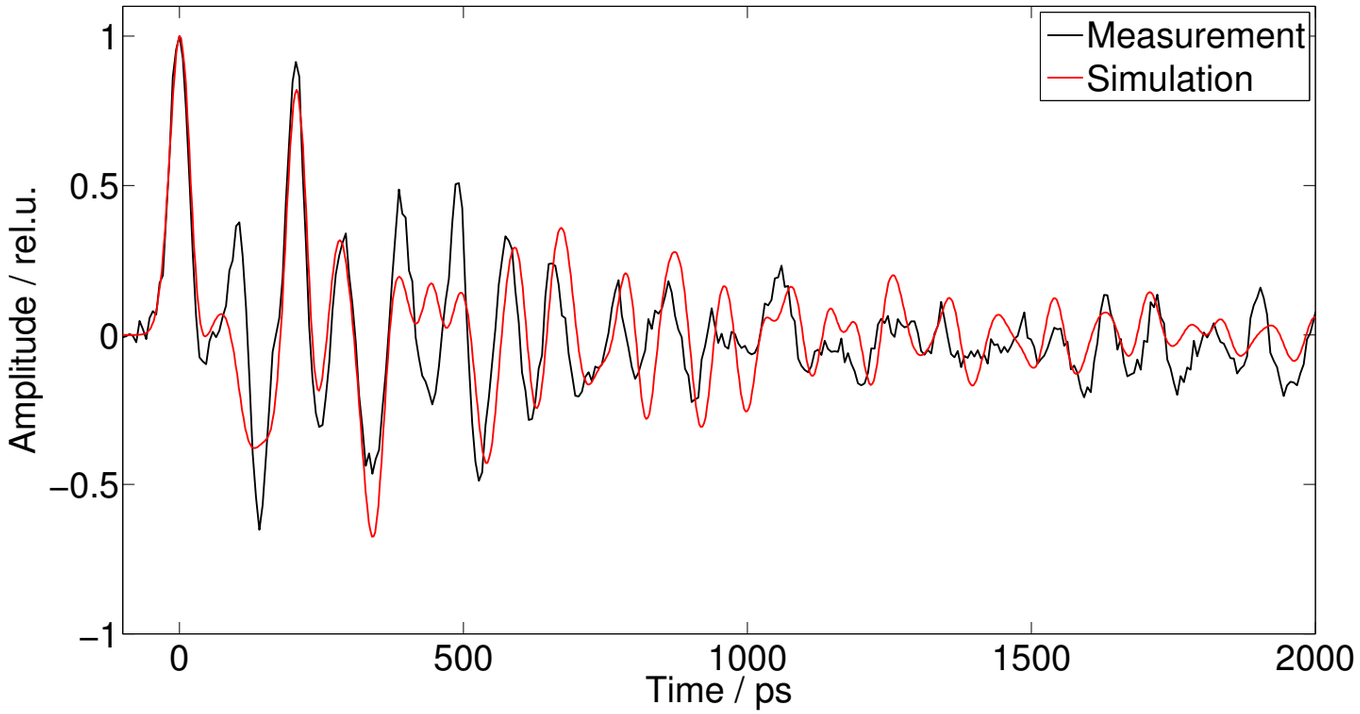




Comparison to simulation







B. Kehrer et al., IPAC'13, MOPEA015