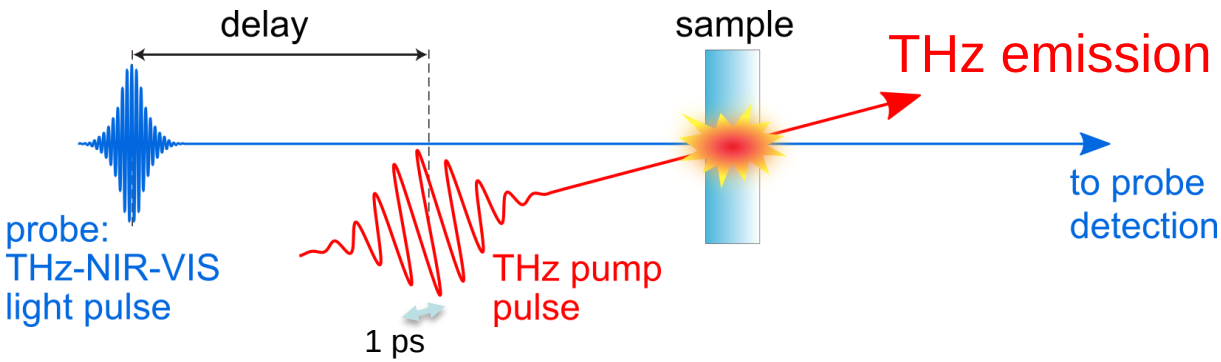
# Current Status and Developments of ultrafast spectroscopy at accelerator based light source ELBE

Sergey Kovalev • s.kovalev@hzdr.de • www.hzdr.de • HZDR

# Ultrafast spectroscopy at 4th generation light sources:

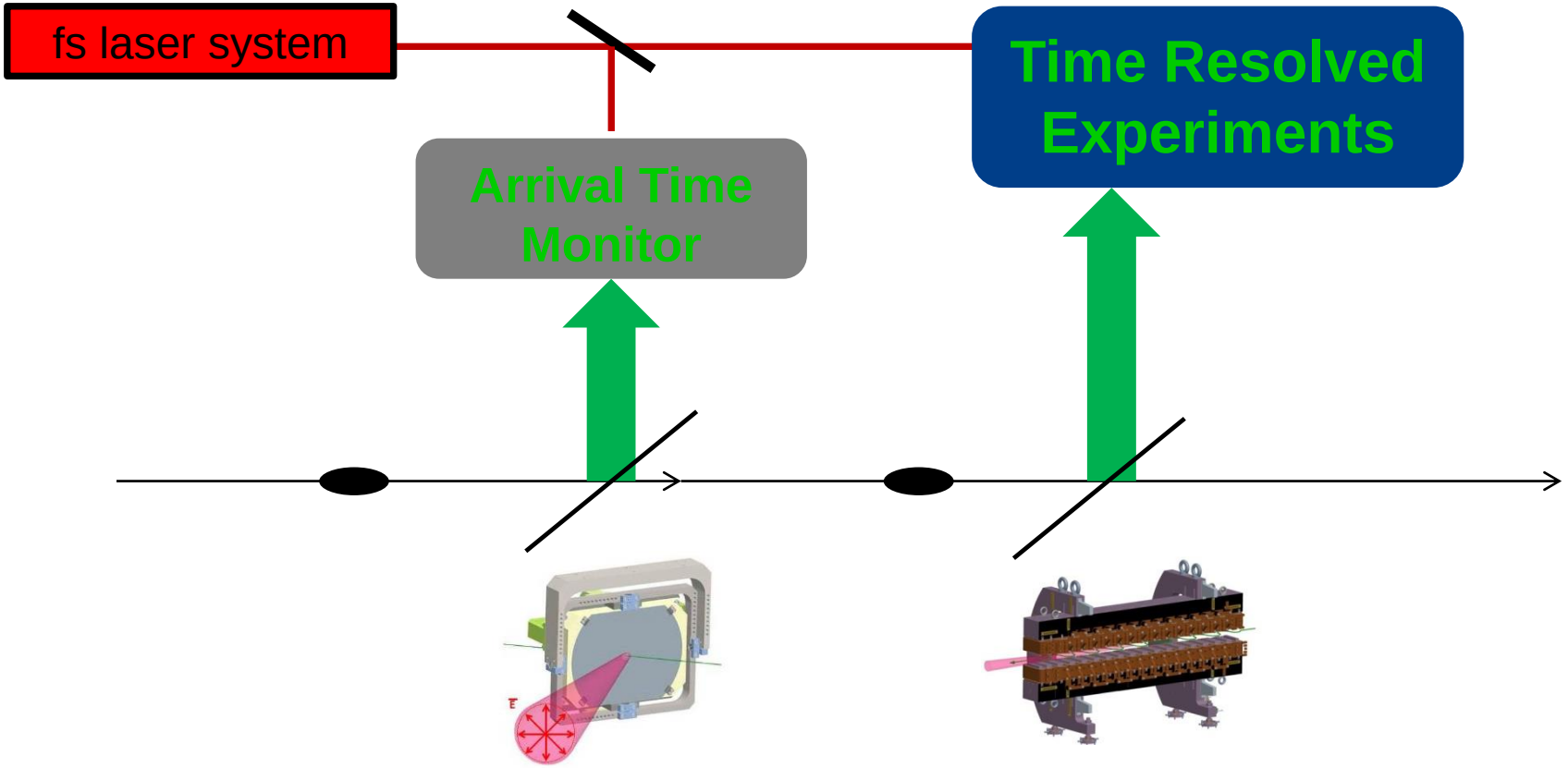



*bringing together:*

a) SRF-linac-driven THz sources

b) table-top fs optical laser

# Pulse resolved detection:



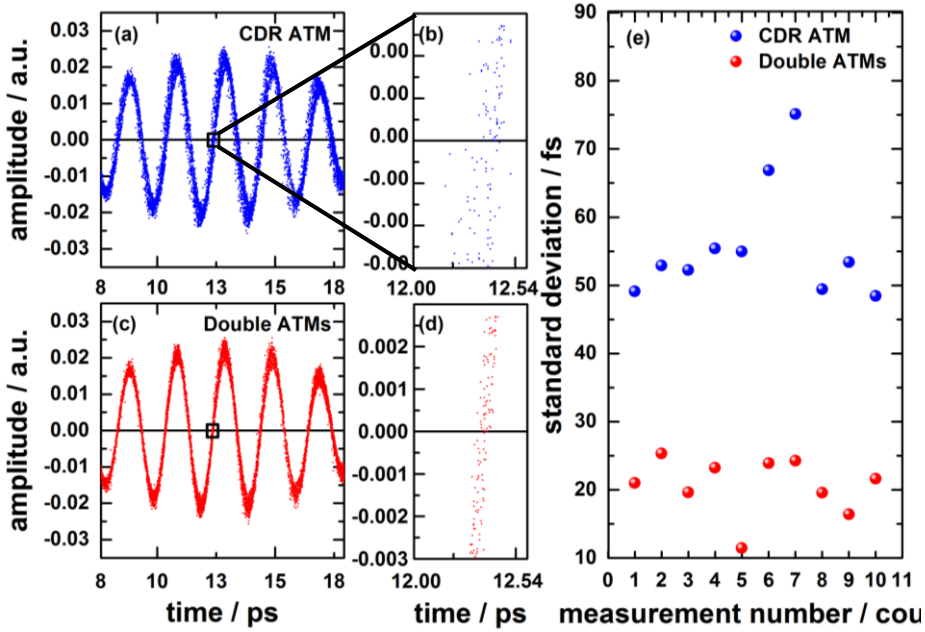

**utilizing intrinsic synchronization of photon pulses from same electron bunch***

1. S. Kovalev et al., Struct. Dyn. 4, 024301 (2017)
2. B. Green et al., Scientific Reports 6, 22256 (2016)

# Comparison between single and sequential ATM

- *Short-term performance (single loop, 5 mins)*
- *Data are sorted but not binned*

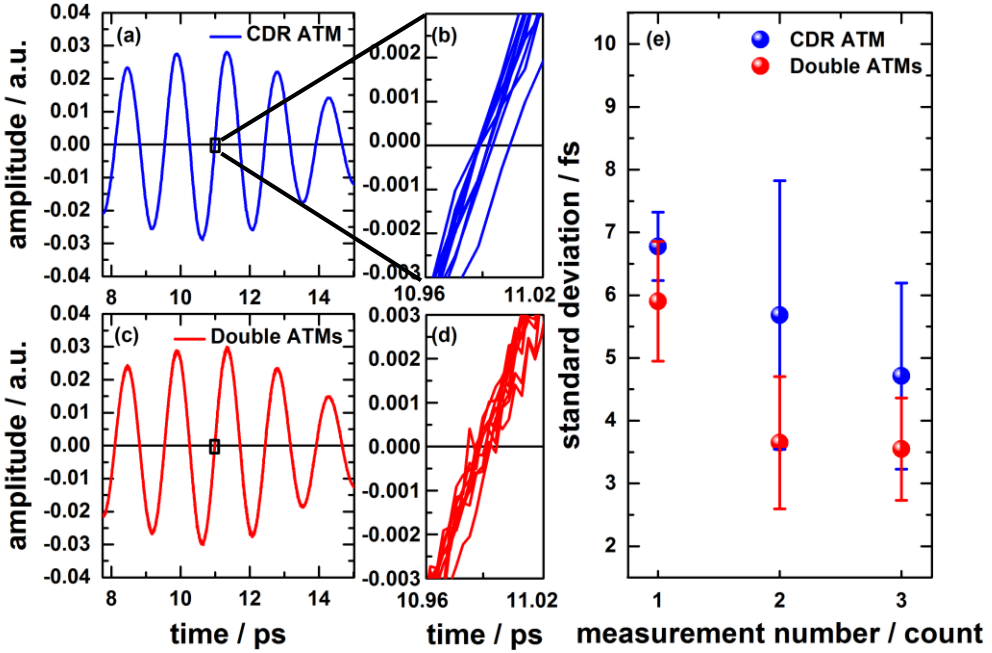
*Zoomed in*




- *Temporal resolution increase from 55 to 20 fs*
- *Short -term jitter compensation*
- *Avoid CDR-undulator jitter.*

- *Long-term performance (10 loops, 30 mins)*
- *Data are sorted and binned*

*Zoomed in*



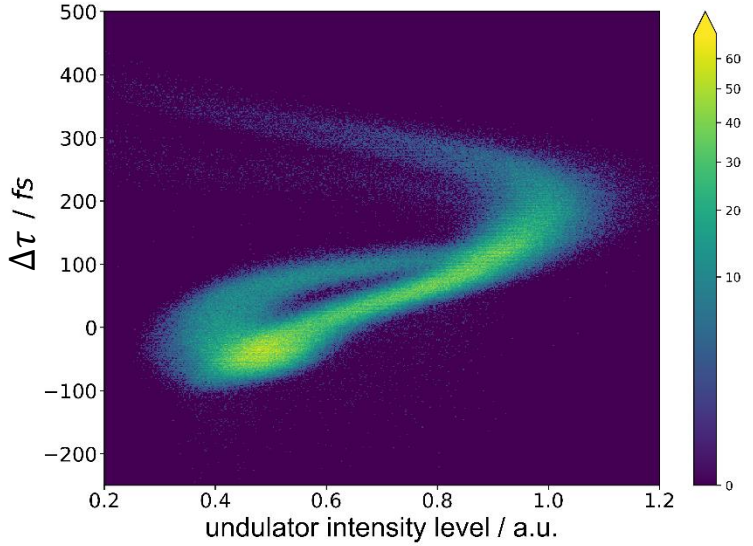

- *Temporal resolution increase from 6 to 4 fs*
- *Long-term drift compensation*
- *Temp. drifts of beamlines.*

- *Temporal resolution is estimated by RMS distribution of data points around zero-crossing positions*

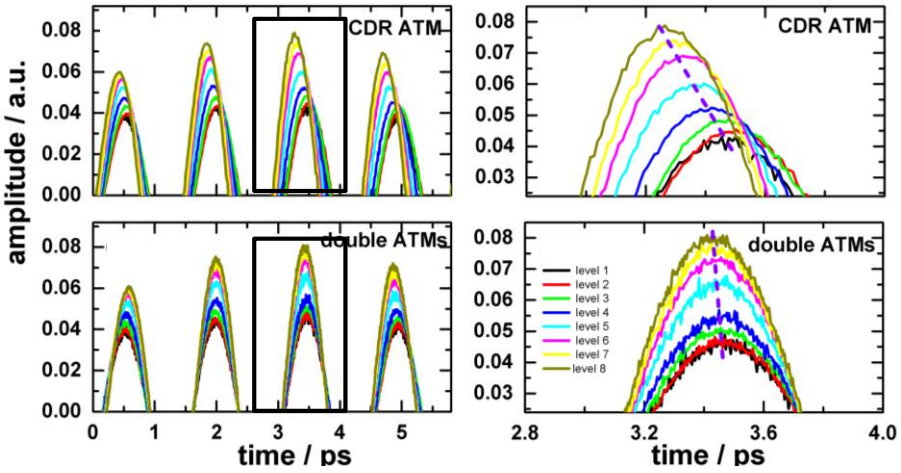
M. Chen et al., Optics Express 27, 32360 (2019)

# Correlation between Arrival time difference and undulator pulse intensity

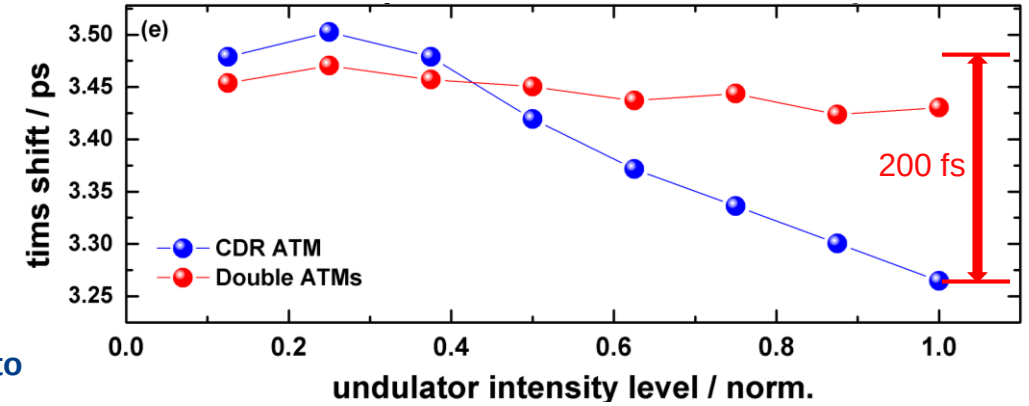
## $\Delta\tau$ vs. undulator intensity level




## EOS trace binned with different undulator intensity level

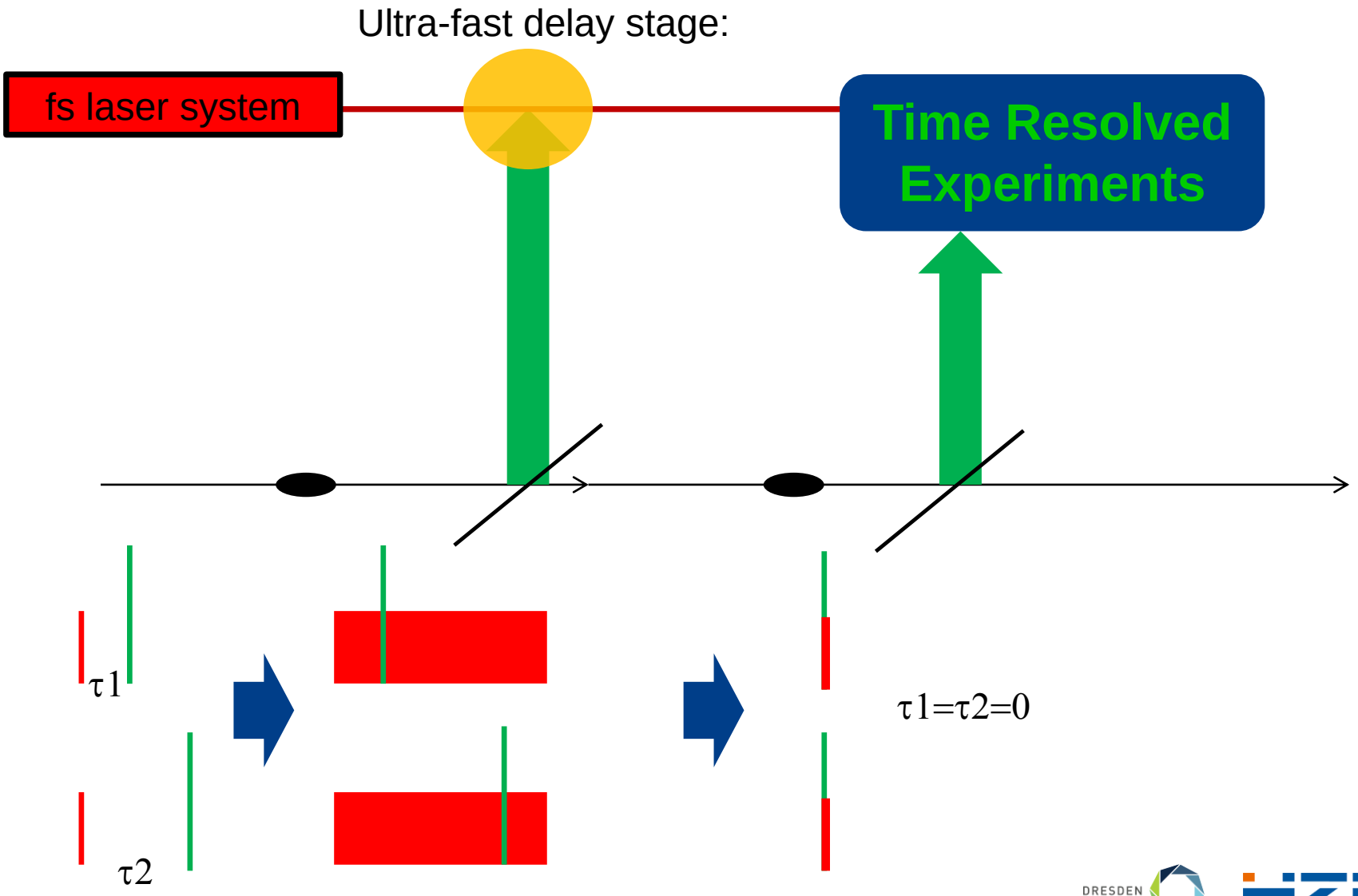



- $\Delta\tau$: **arrival time difference between CDR and undulator pulse**
- **Undulator intensity level: read out from undulator ATM**



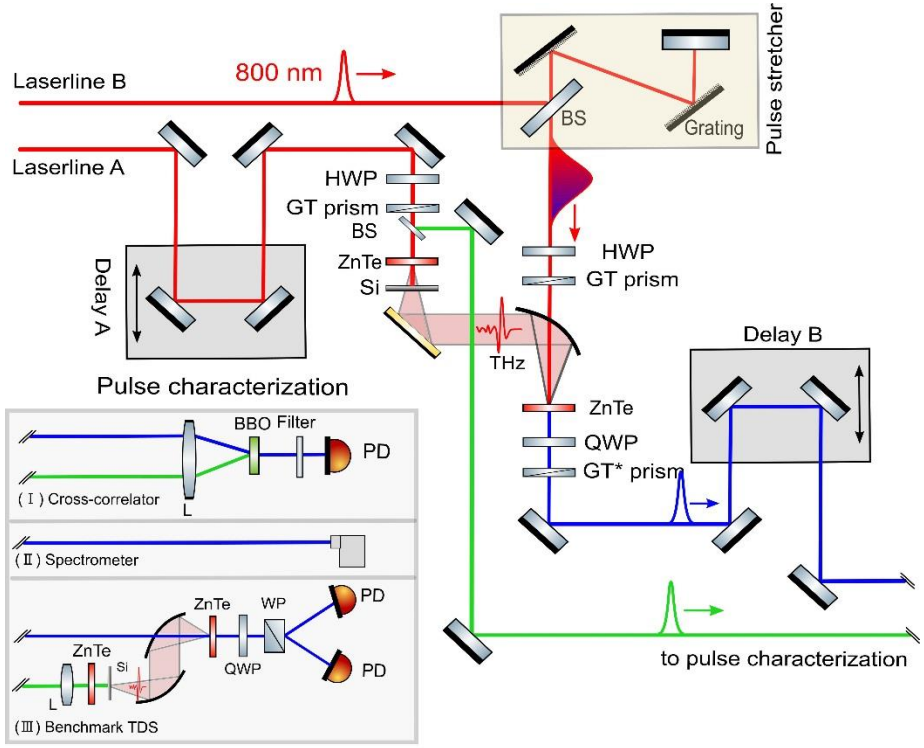

- **Increase timing accuracy by decreasing pulse intensity correlated arrival time shift**
- **!!!Could be a new diagnostic tool investigating electron energy charge dispersion between undulato and CDR source !!!**

# Intrinsic synchronization:

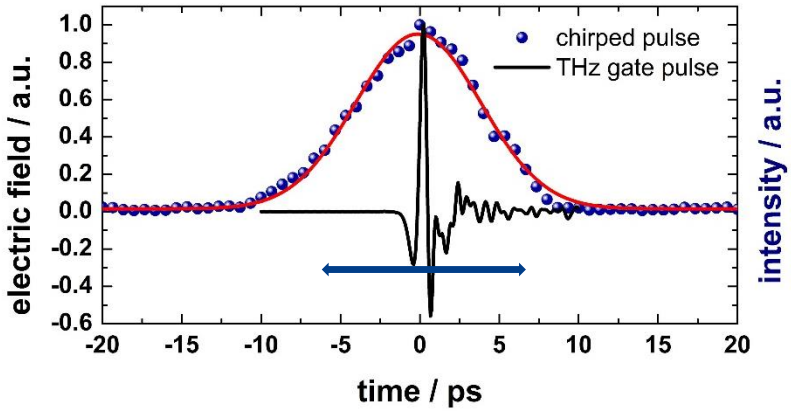



*M. Chen et al., Optics Letters 43, 2213-2216 (2018)*

## Table top experiment



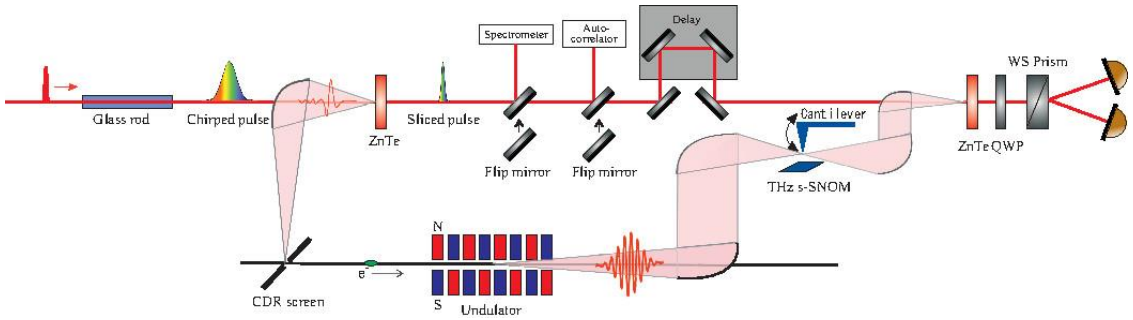

## THz slicing

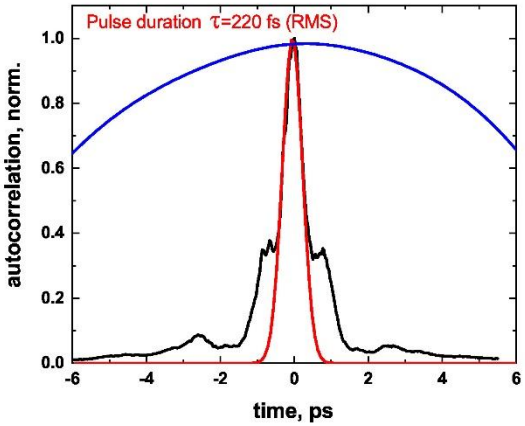


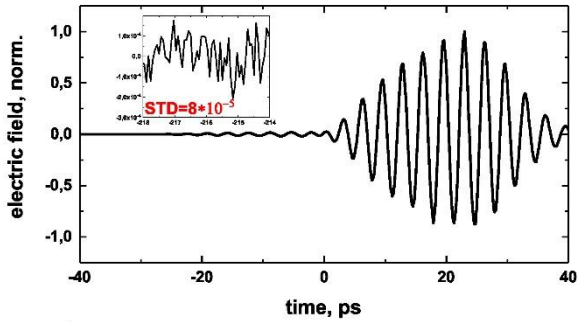

- Delay A: emulate jitter source
- Single cycle THz pulse: emulated CDR pulse

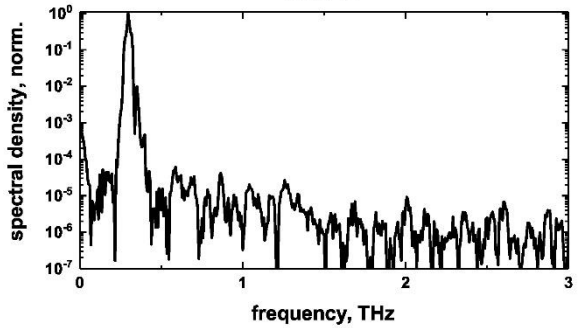
*M. Chen et al., Optics Letters 43, 2213-2216 (2018)*

# Intrinsic synchronization: at accelerator-based light

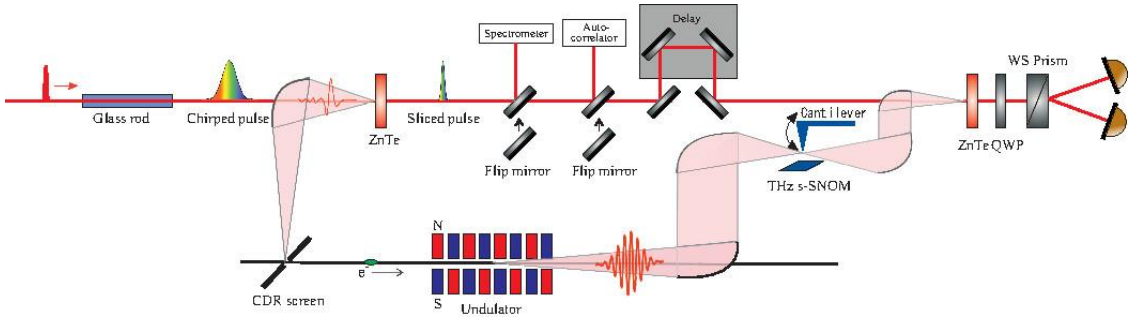


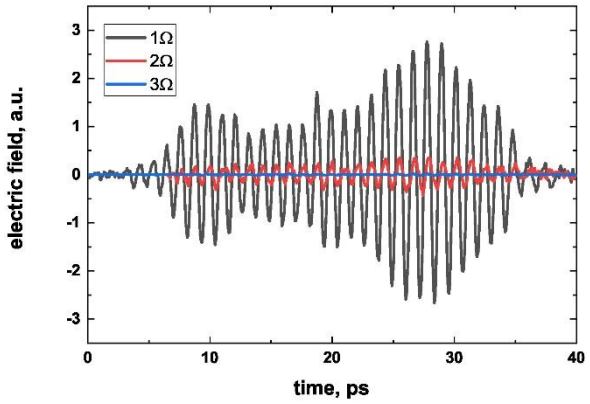



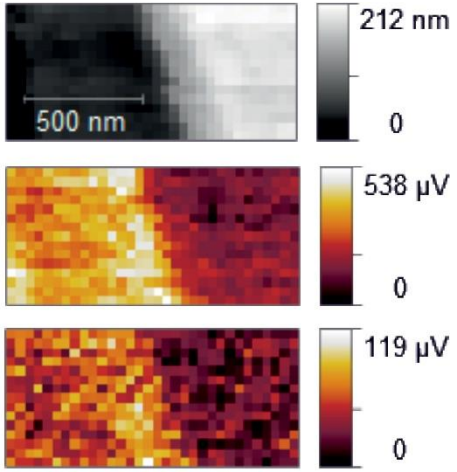



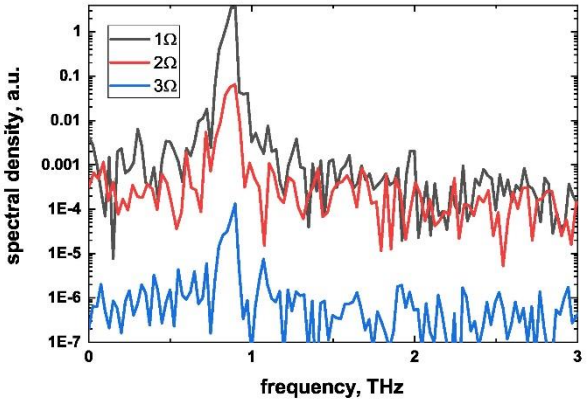



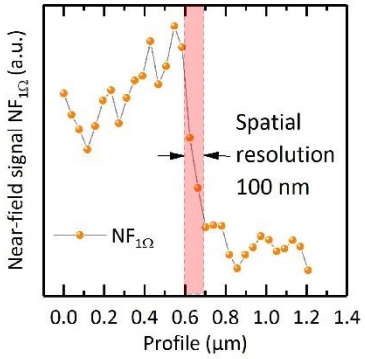
# tr-SNOM at accelerator based light sources



Further work:

- Wavelength jitter: Fourier limited long laser pulses implementation
- Sliced pulse amplification: nJ – 100 nJ
- Duration compression: sub 100 fs (case of TELBE)
- Contrast improvements: …

# Thank you for your attention.