Electron Bunch Diagnostic at the Upgraded ELBE Accelerator: Status and Challenges

International Beam Instrumentation Conference

Oxford, UK

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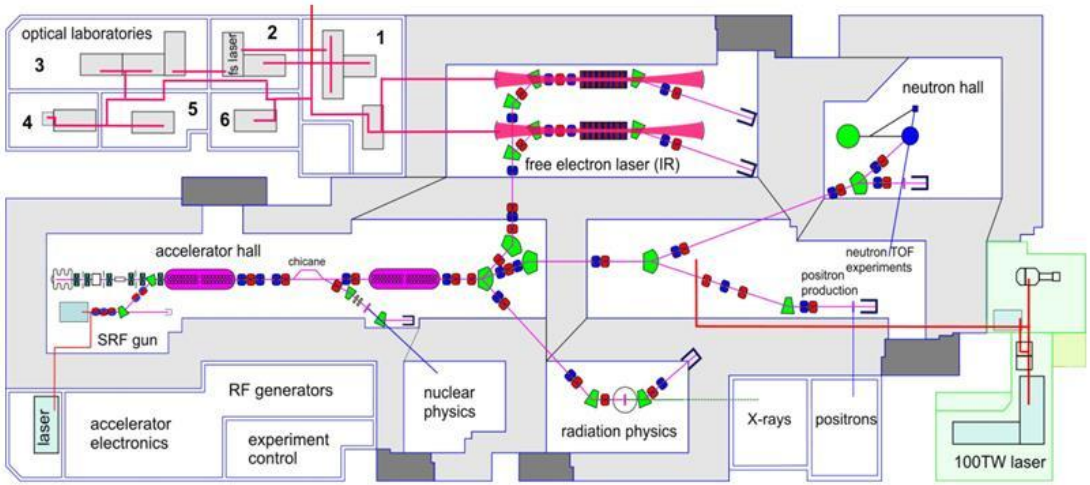
E. Hass (Uni HH, Hamburg)

HELMHOLTZ ZENTRUM DRESDEN ROSSENDORF

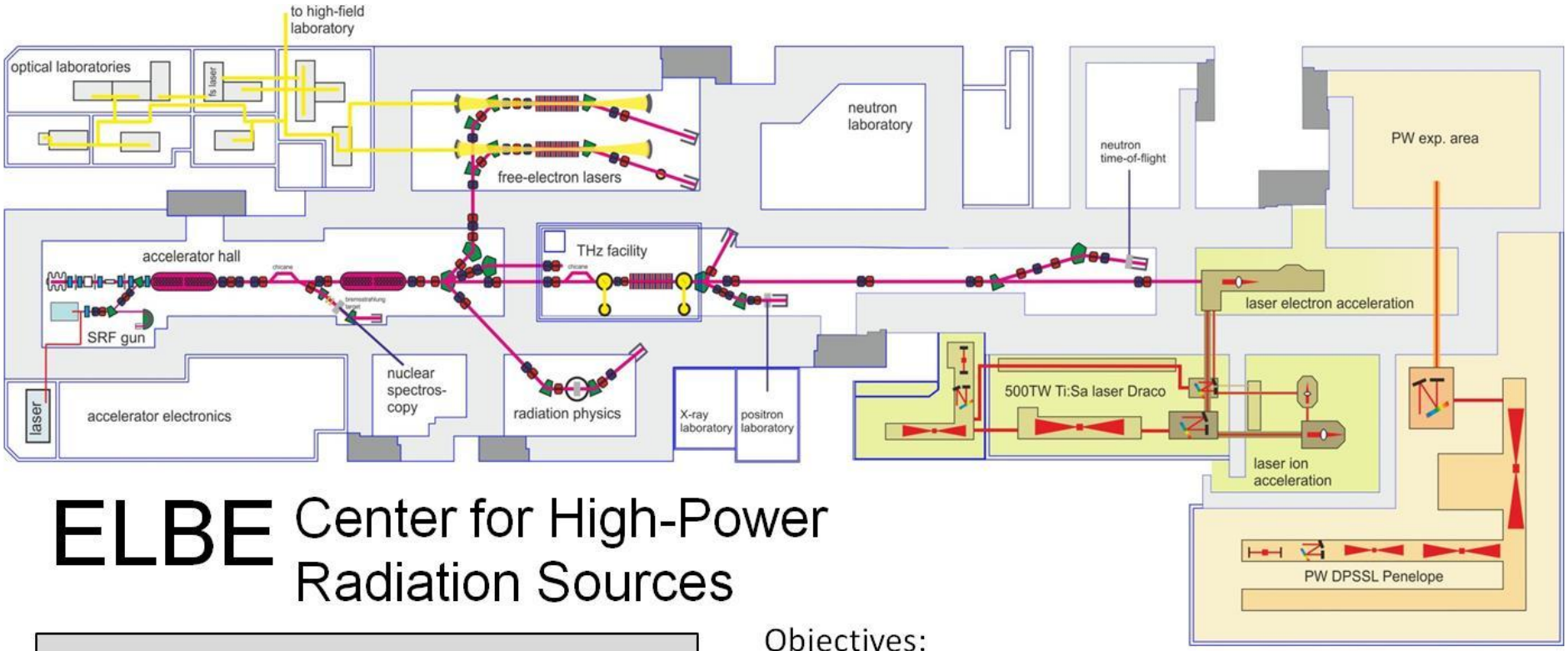


ELBE Radiation Source

Electron energy [MeV]	8 – 40
max. CW rep. rate [MHz]	26
avg. beam current [µA]	1000
max. bunch charge [pC]	100
min. bunch length [ps]	2

Objectives:

- 1.6 mA average beam current
- new THz facility
- tunable Thomson X-ray source
- lab space for:
  - 500 TW Laser “DRACO”
  - PW Laser “PEnELOPE”



ELBE Center for High-Power Radiation Sources

Electron energy [MeV]	8 – 40
max. CW rep. rate [MHz]	26
avg. beam current [µA]	**1600**
max. bunch charge [pC]	**1000** (tbd)
min. bunch length [ps]	**0.2**

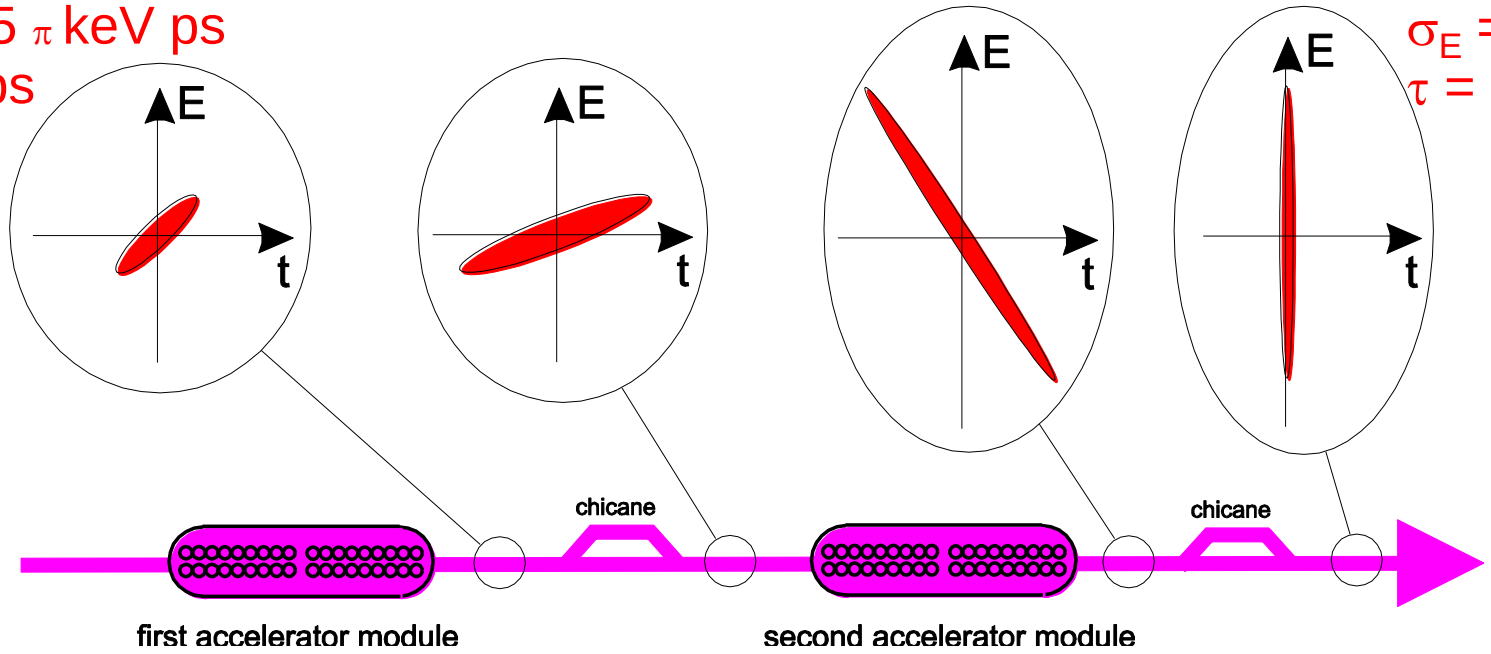
Objectives:

- 1.6 mA average beam current
- new THz facility
- tunable Thomson X-ray source
- lab space for:
  - 500 TW Laser “DRACO”
  - PW Laser “PEnELOPE”

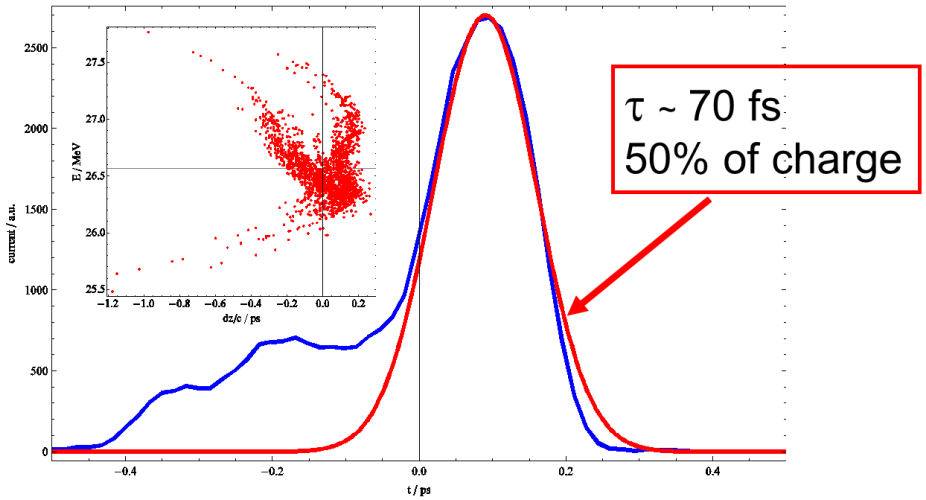
Bunch Compression Scheme

C = 77 pC
ε_E = 35 π keV ps
τ = 2 ps

E = 28 MeV
σ_E = 250 keV
τ = 150 fs



Courtesy U. Lehnert



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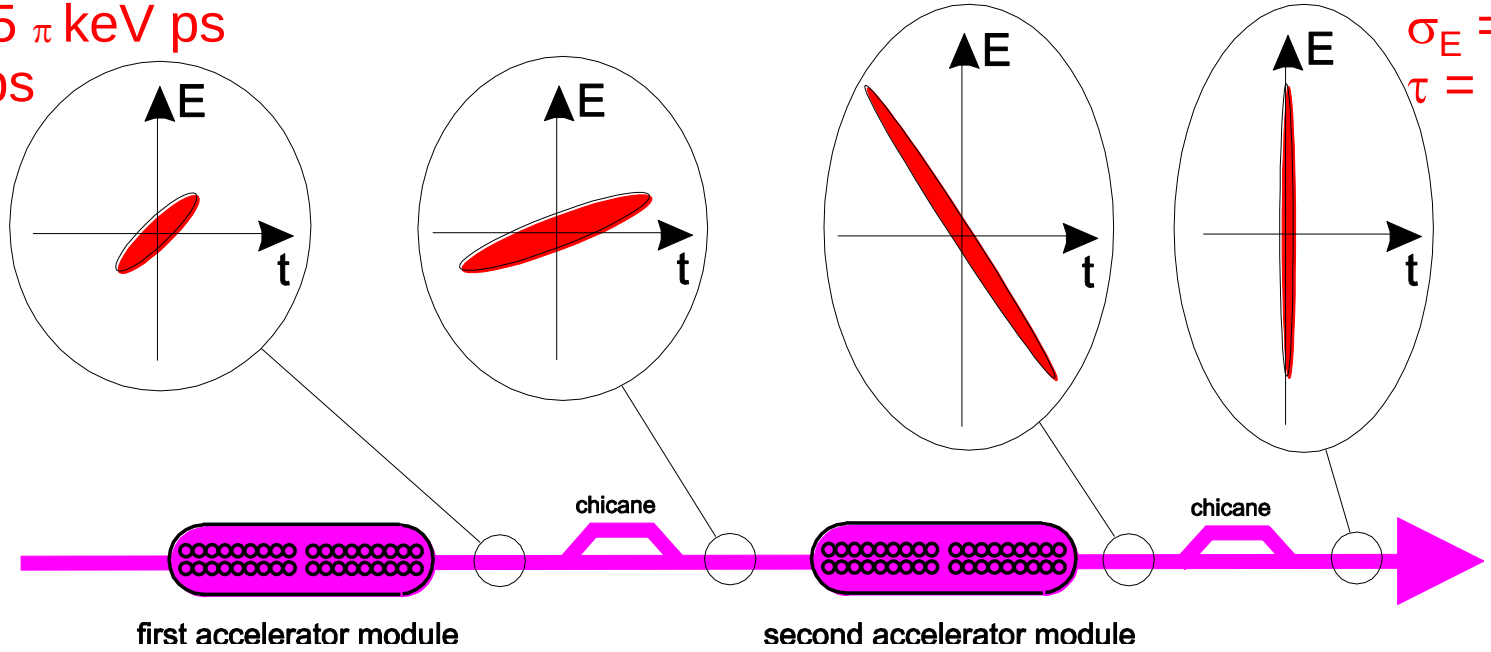


Courtesy U. Lehnert

$$\sum_t^2 \approx \left(\frac{R_{56}}{c_0}\frac{\sigma_A}{A}\right)^2 + \left(\frac{C-1}{C}\right)^2 \left(\frac{\sigma_\varphi}{2\pi f RF}\right)^2 + \left(\frac{1}{C}\right)^2 \sum_{i,t}^2$$

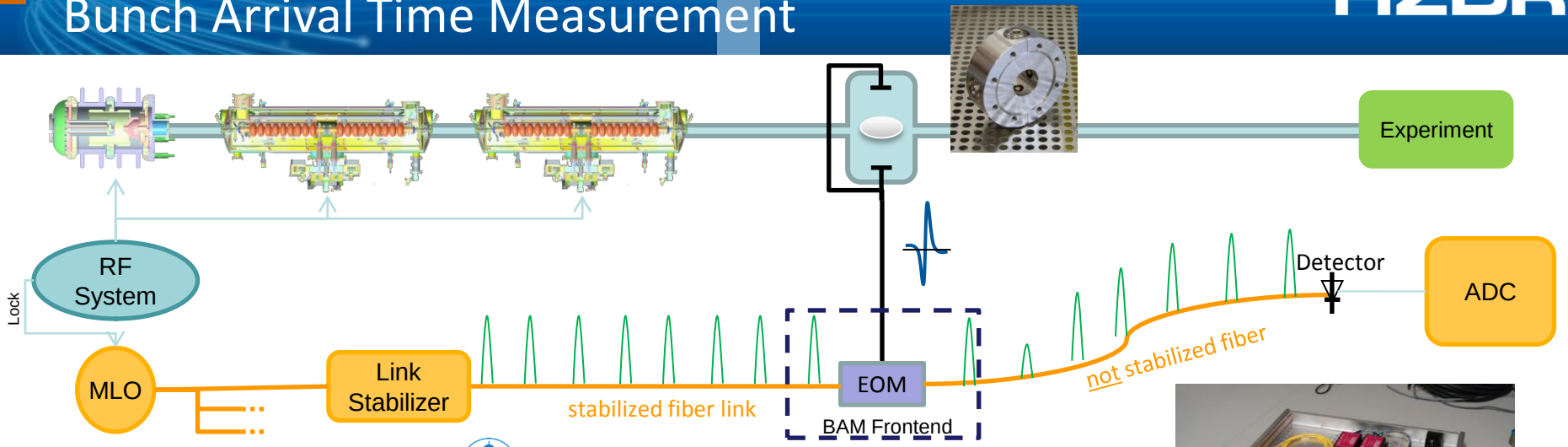
↑ cavity amplitude jitter

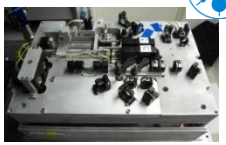
↑ cavity phase jitter

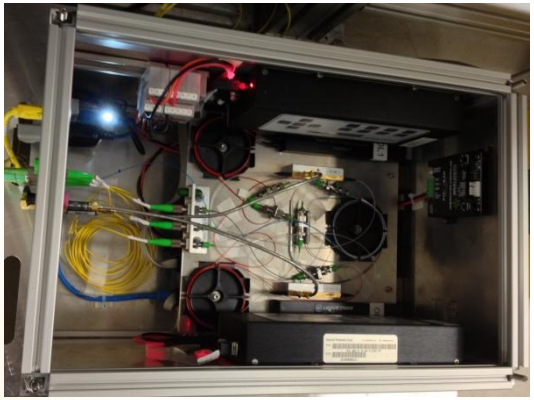
↑ injector jitter

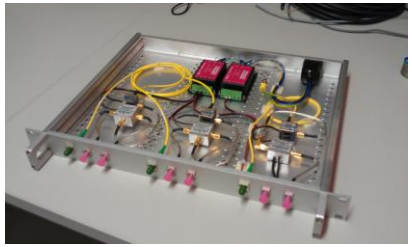
C… compression factor

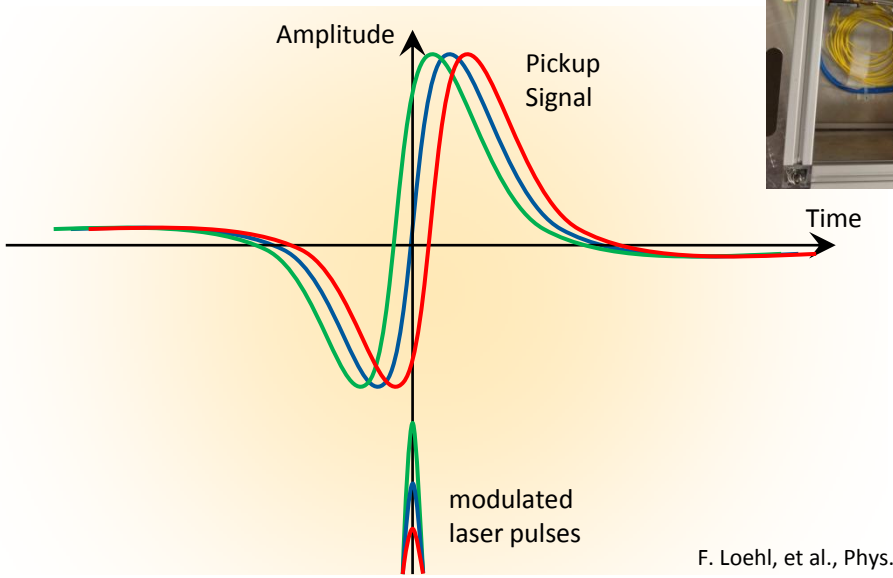
Bunch Arrival Time Measurement









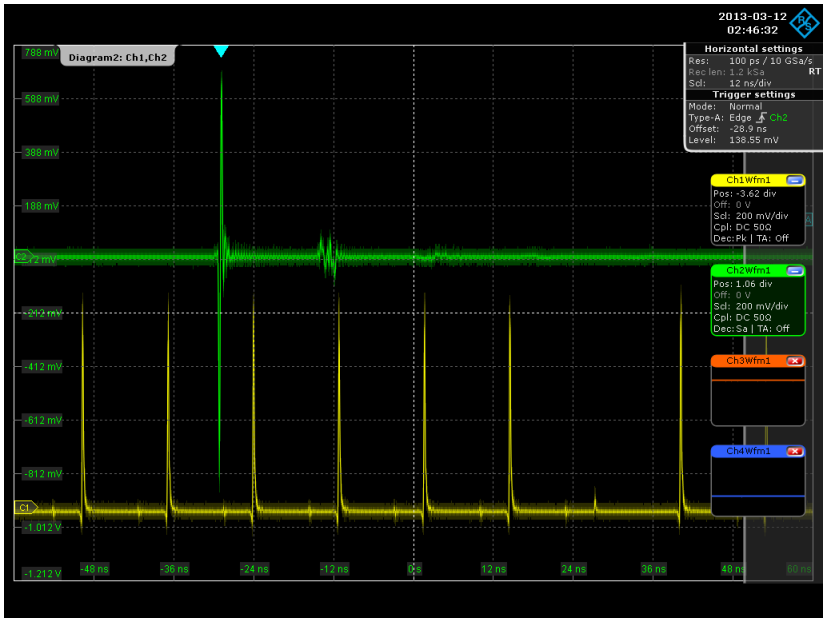


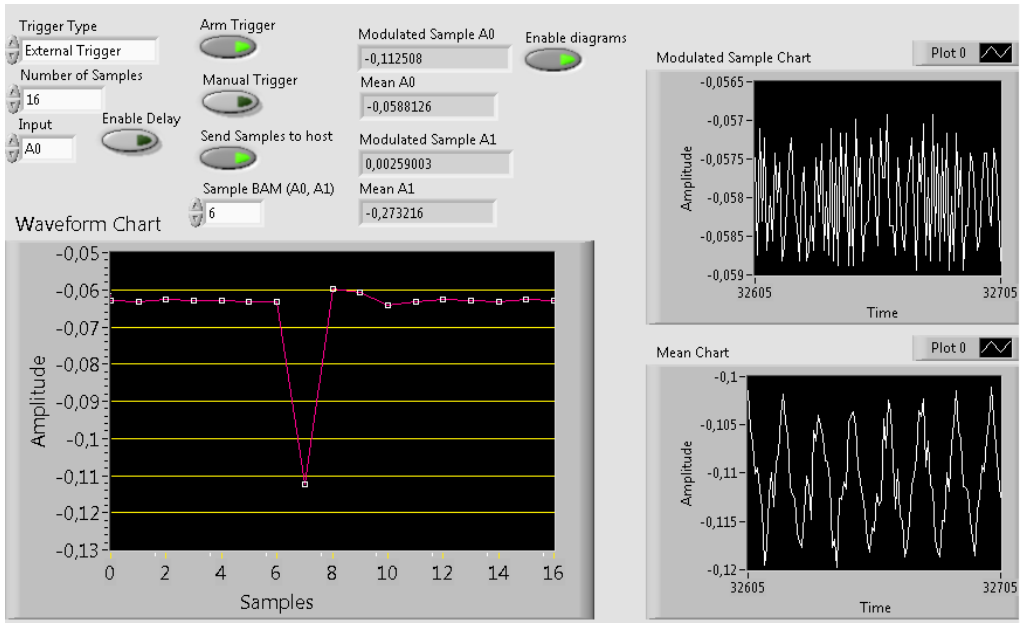
Bunch Arrival Time Monitor (BAM)

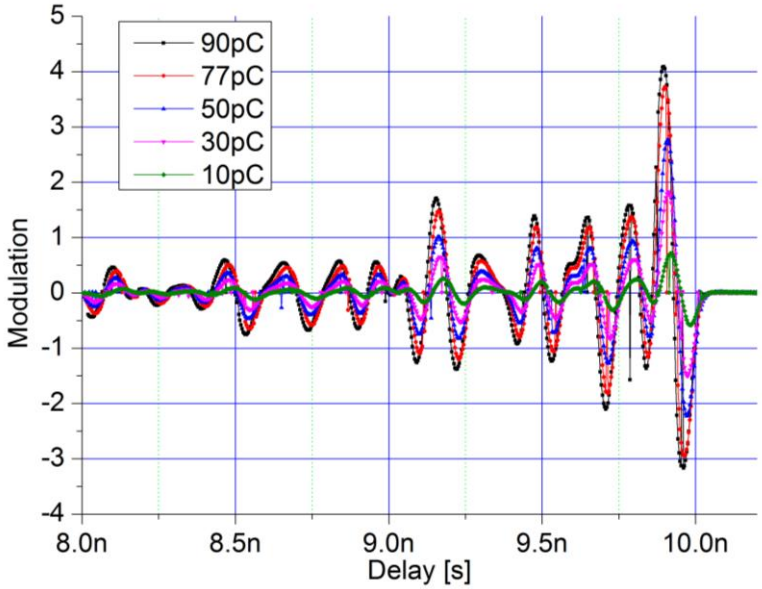
- timing information coded to laser pulse amplitude
- bunch arrival time w.r.t. optical master clock
- single bunch resolution

F. Loehl, et al., Phys. Rev. Lett., Volume 104, Issue 14, 144801 (2010)

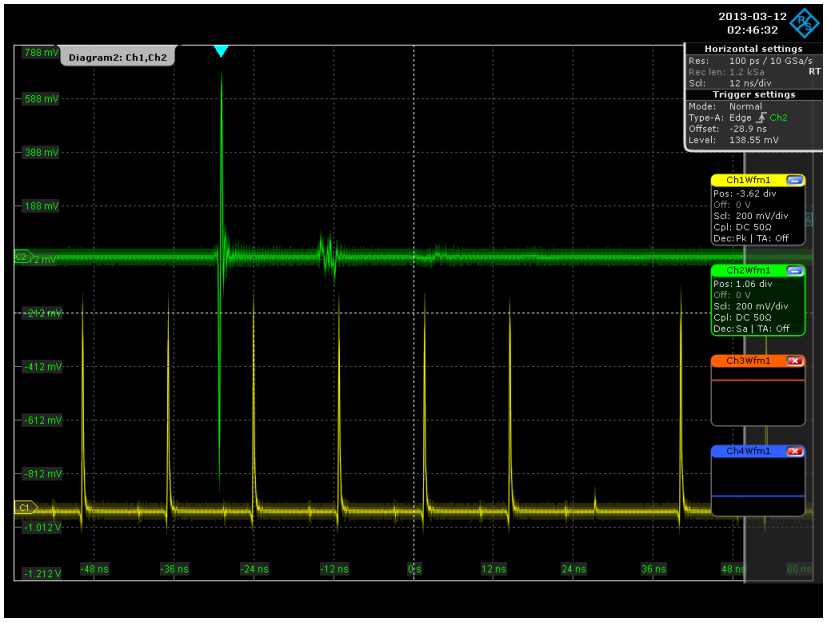
Bunch Arrival Time Measurement

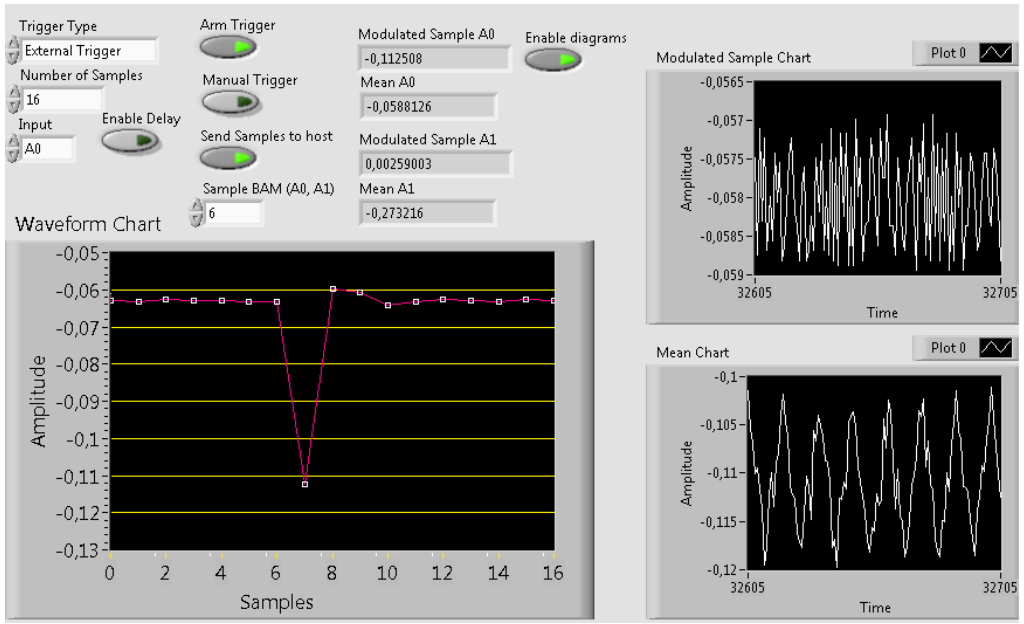


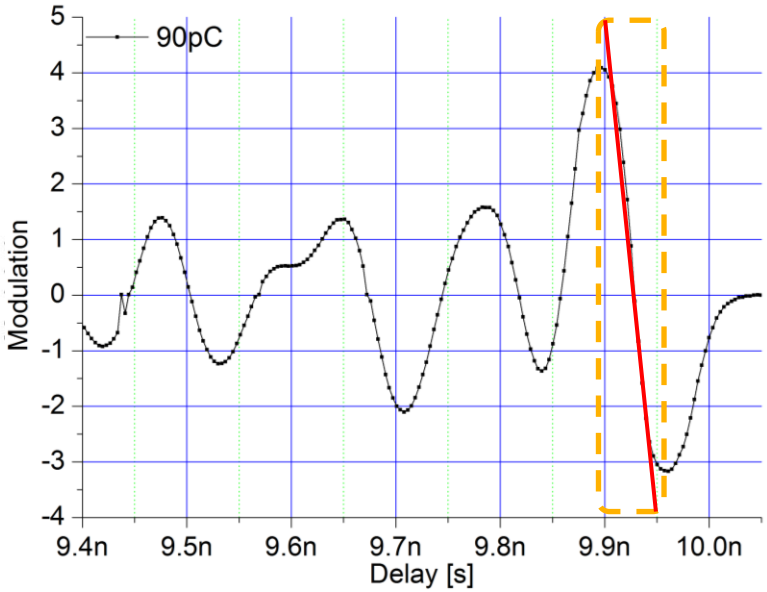




Bunch Arrival Time Measurement







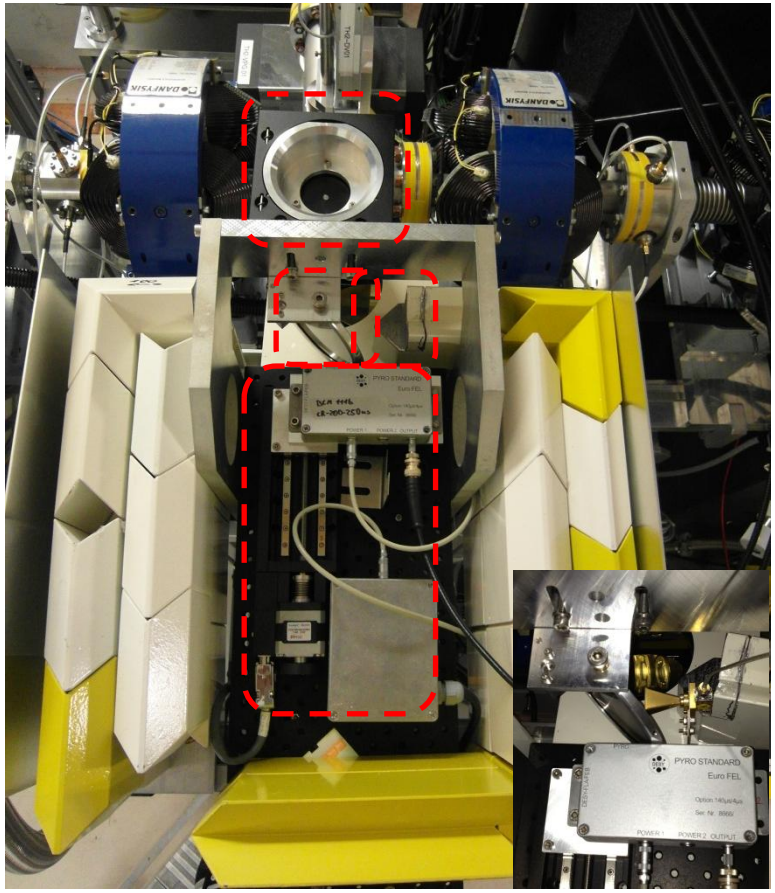
First results for 90 pC

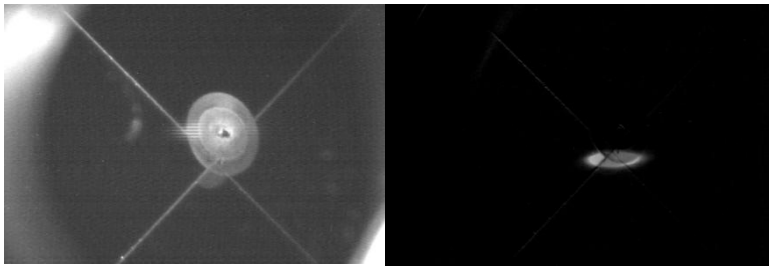
- 40 ps slope for full modulation
- ~ 300 fs resolution

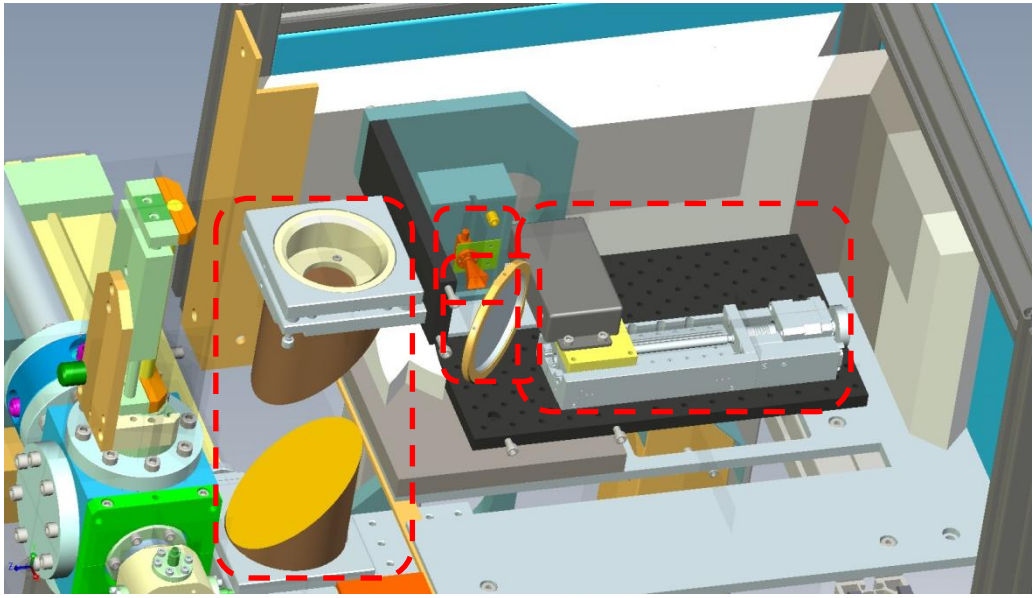
Next steps:

- installation of broadband pickups for higher sensitivity

Bunch Compression Measurement

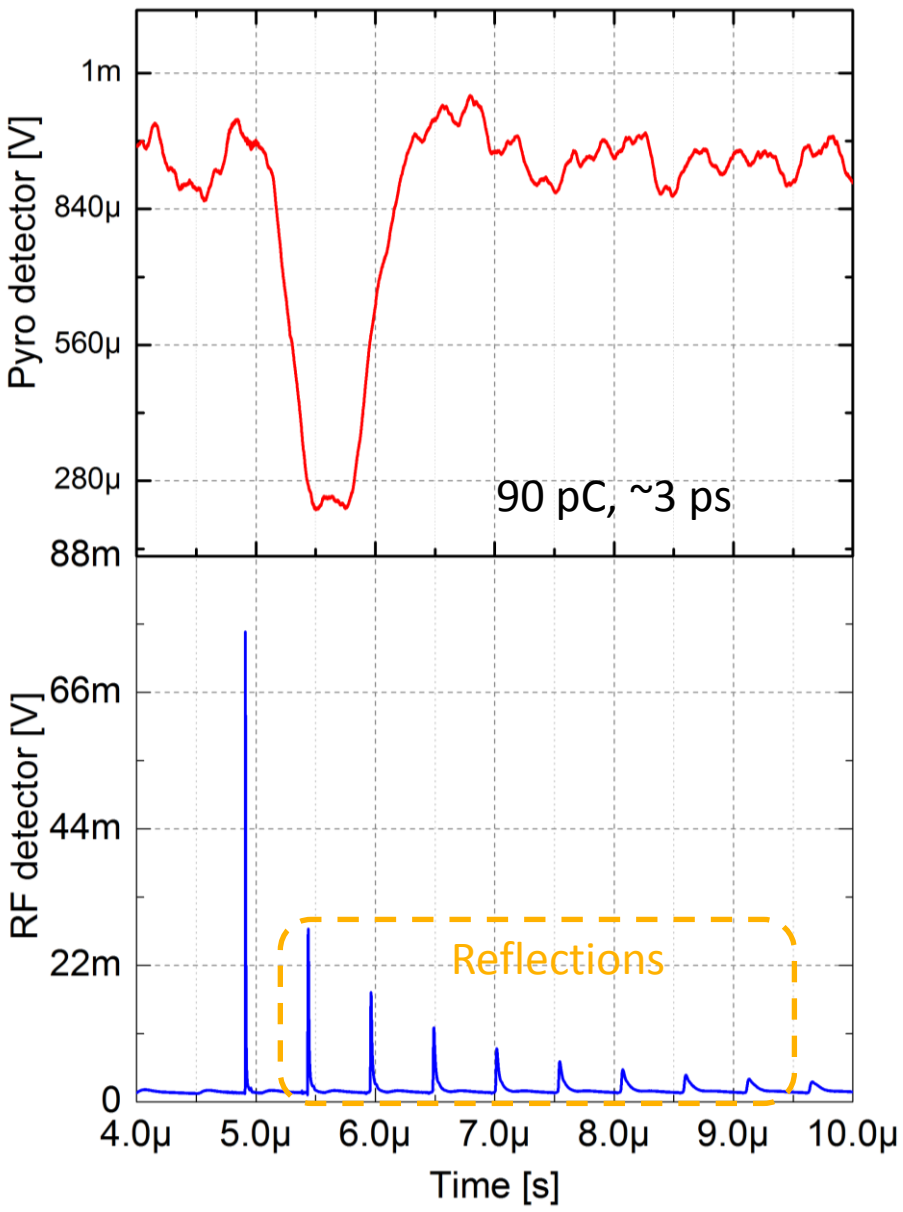


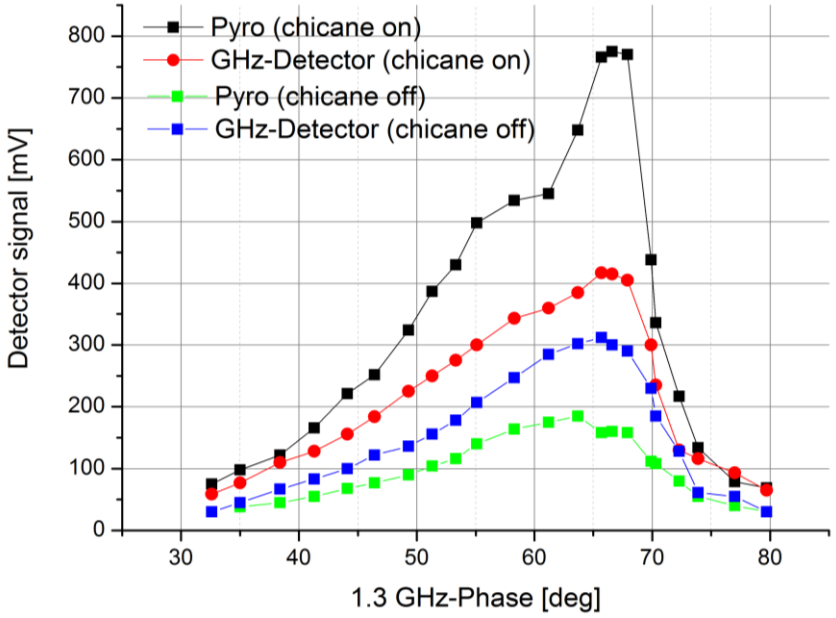


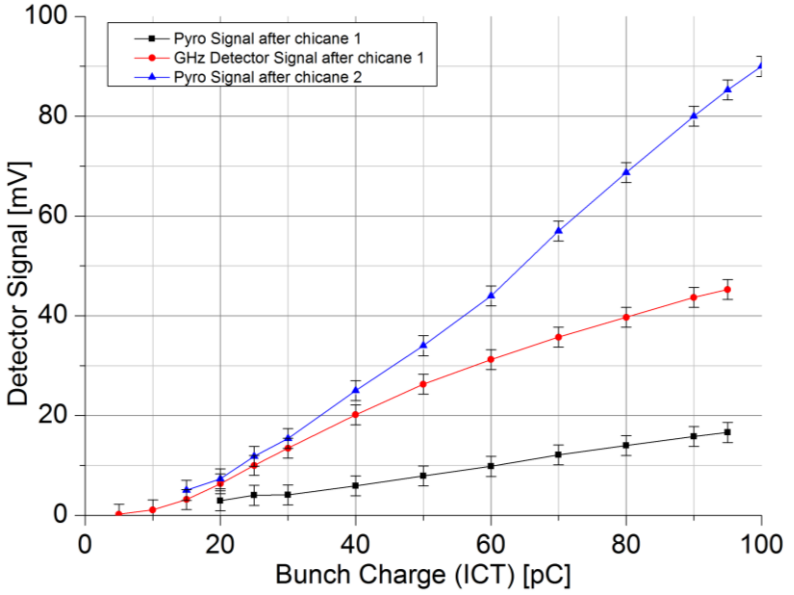


- Pyroelectric detector (movable)
- Schottky diode RF Detector (fixed)
- Wire grid as beam splitter for parallel measurements
- Silicon OTR screen
- measurements up to 10 µA (ELBE diagnostic mode limit)
- additional ODR screen for noninvasive measurements (to be installed)
- Combined view screen/ BCM Station

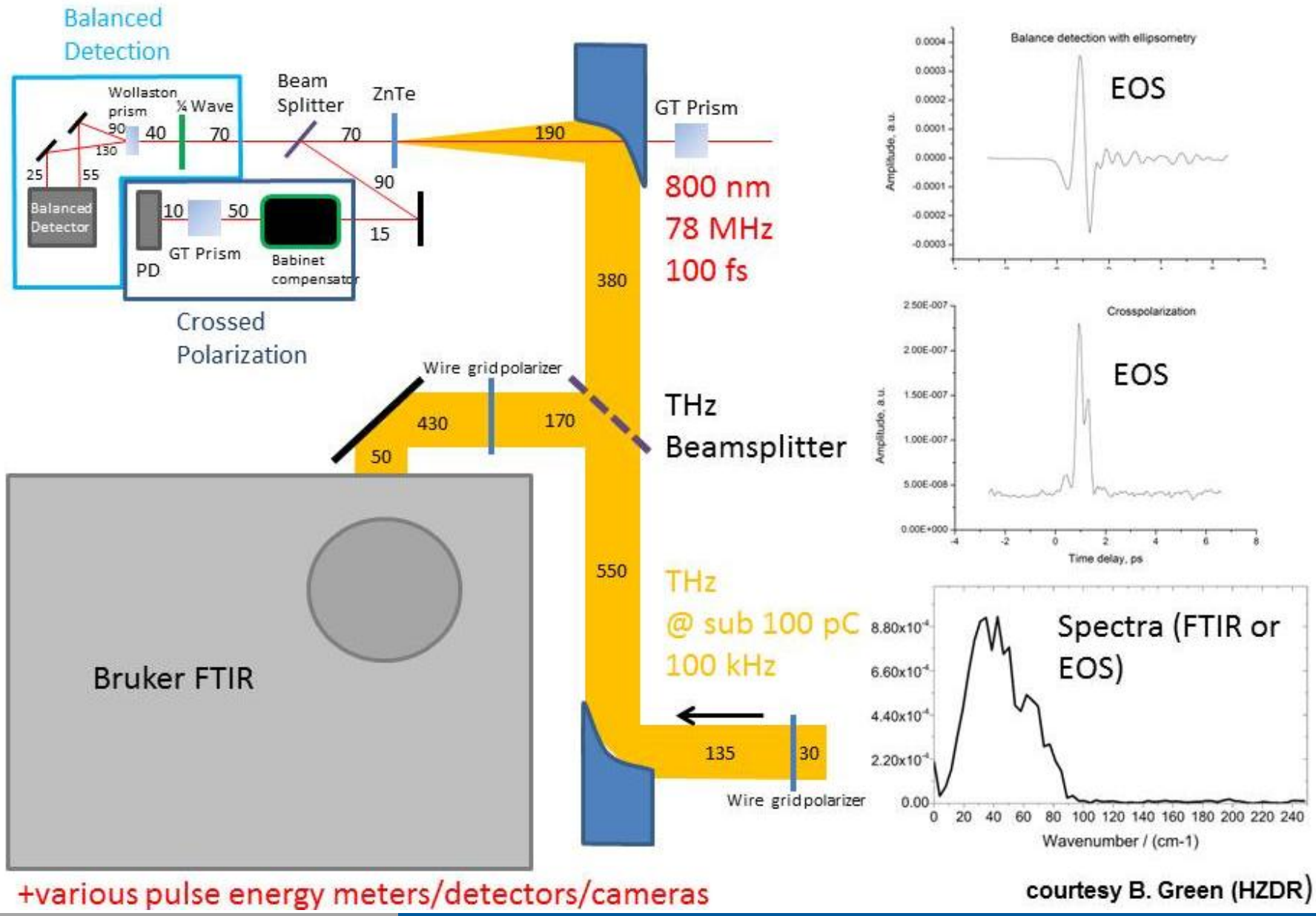
Bunch Compression Measurement





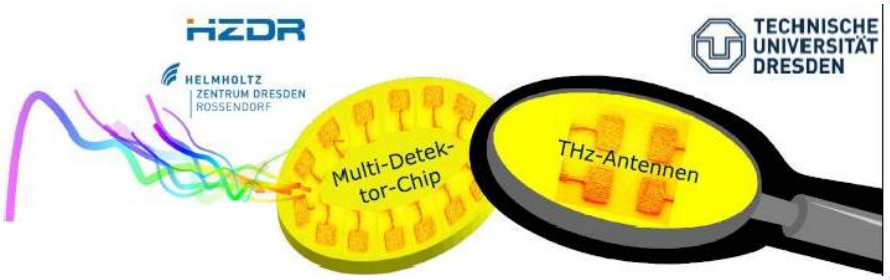


Electro Optical Sampling

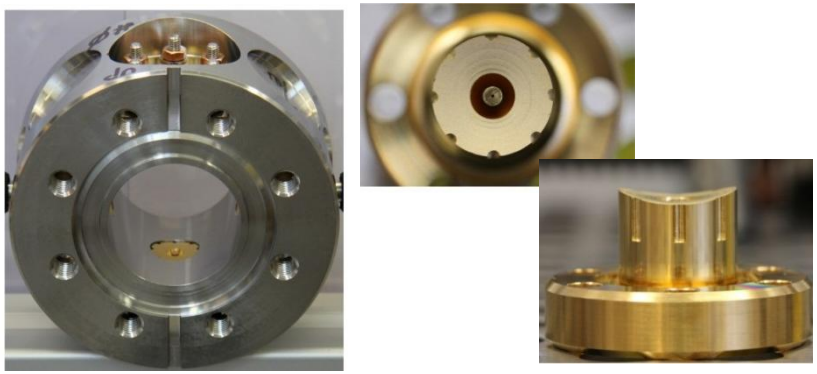


Outlook

Spectral resolved BCM

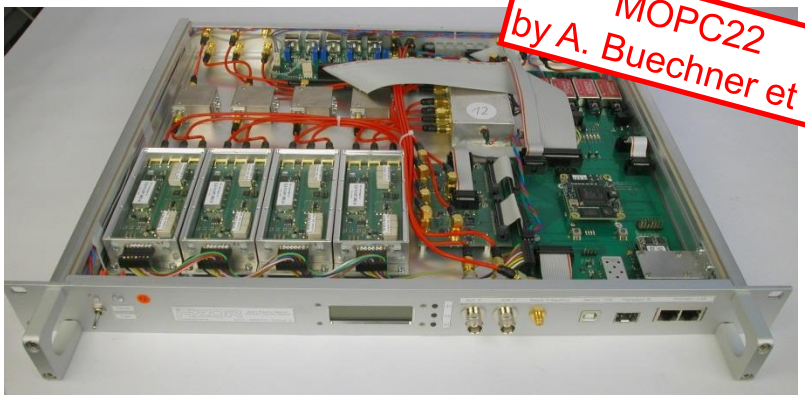


40 GHz BAM for better resolution at low charge

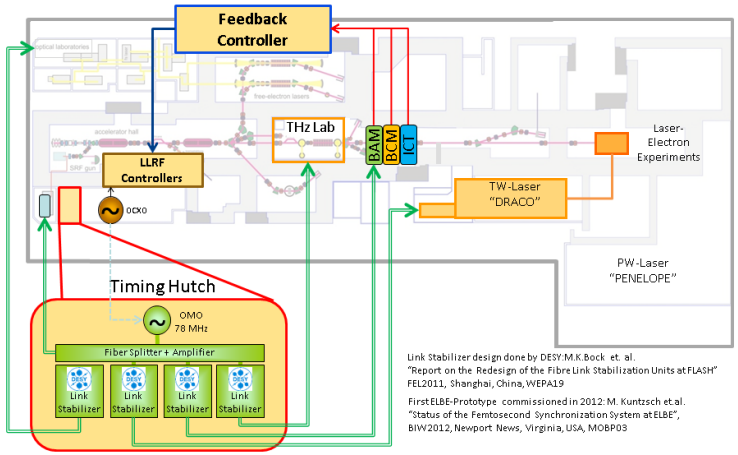


A.Angelovski et.al., Proceedings of IBIC2012, Tsukuba, Japan

Commissioning of new BPM/DCM electronics



BAM, BCM, ICT feedbacks



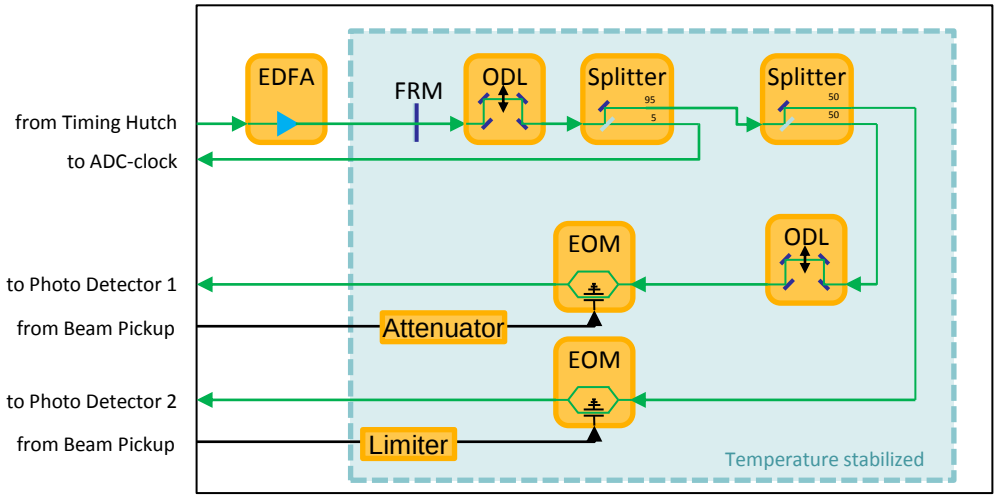
Conclusion

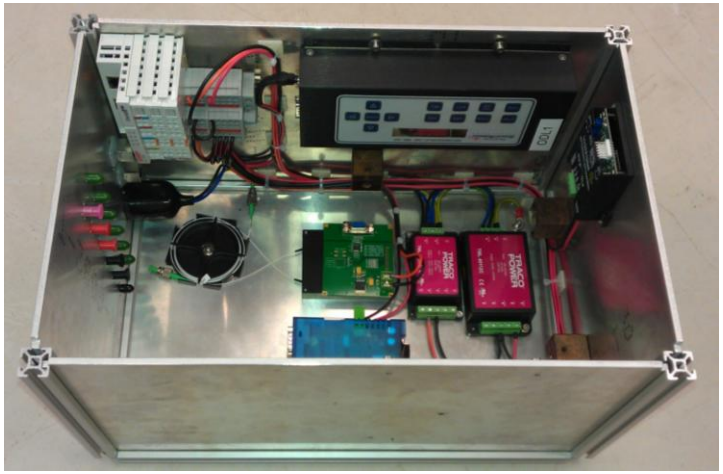
- Commissioning of the Bunch Arrival Time Monitor at ELBE
- First results from Bunch compression monitor
- First light out of both new THz sources
- First results of THz-based Electron Bunch Diagnostics

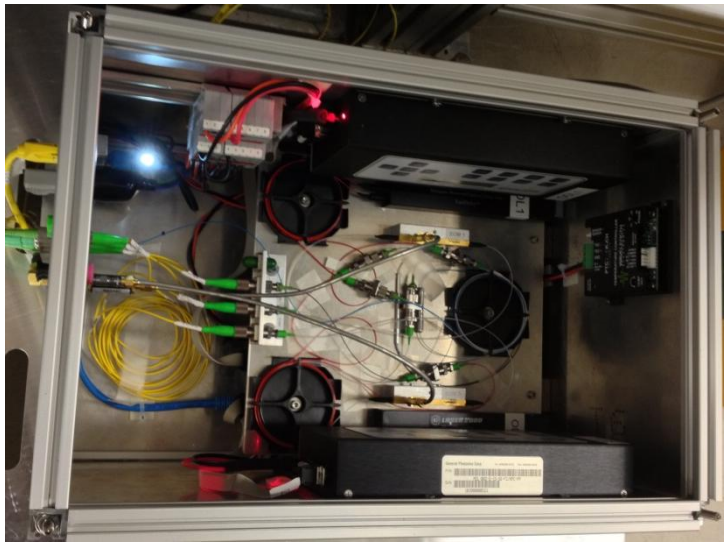
MOPC38
by R. Schurig

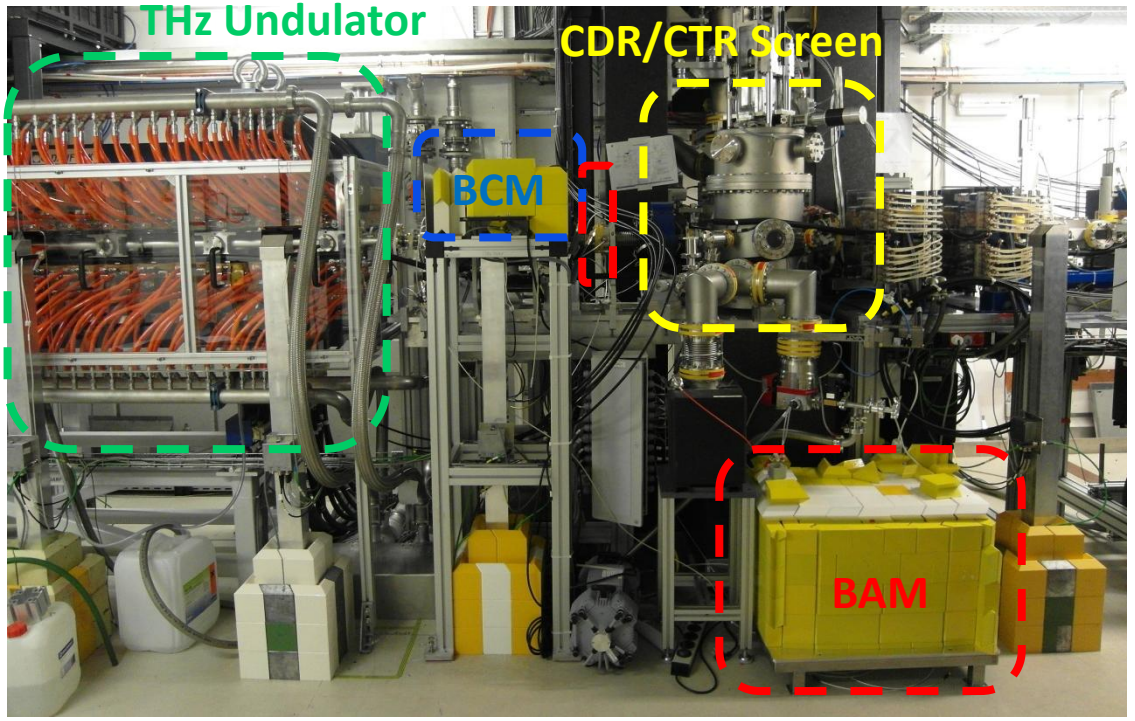
S. Findeisen, M. Gensch, B. W. Green, J. Hauser, S. Kovalev, U. Lehnert, P. Michel, F. Roeser, C. Schneider, R. Schurig, C. Kaya, A. Al-Shemmary, M. Bousonville, M. K. Czwalinna, T. Golz, H. Schlarb, B. Schmidt, S. Schulz, N. Stojanovic, S. Vilcins , E. Hass

Bunch Arrival Time Measurement

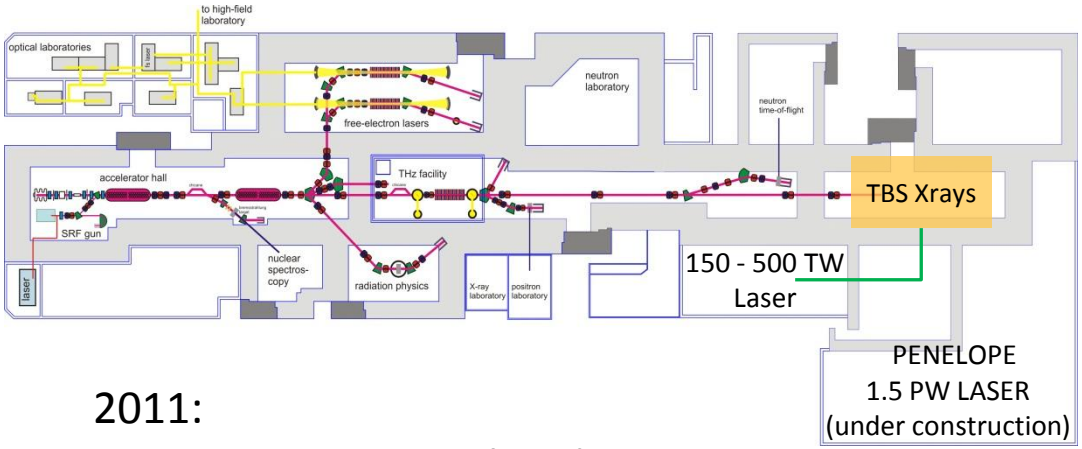


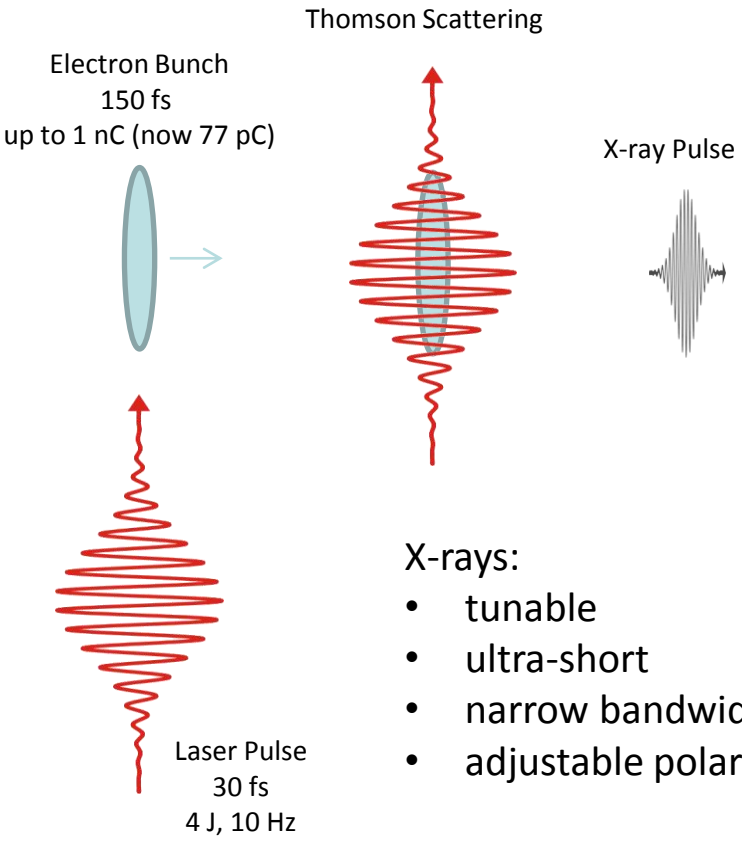




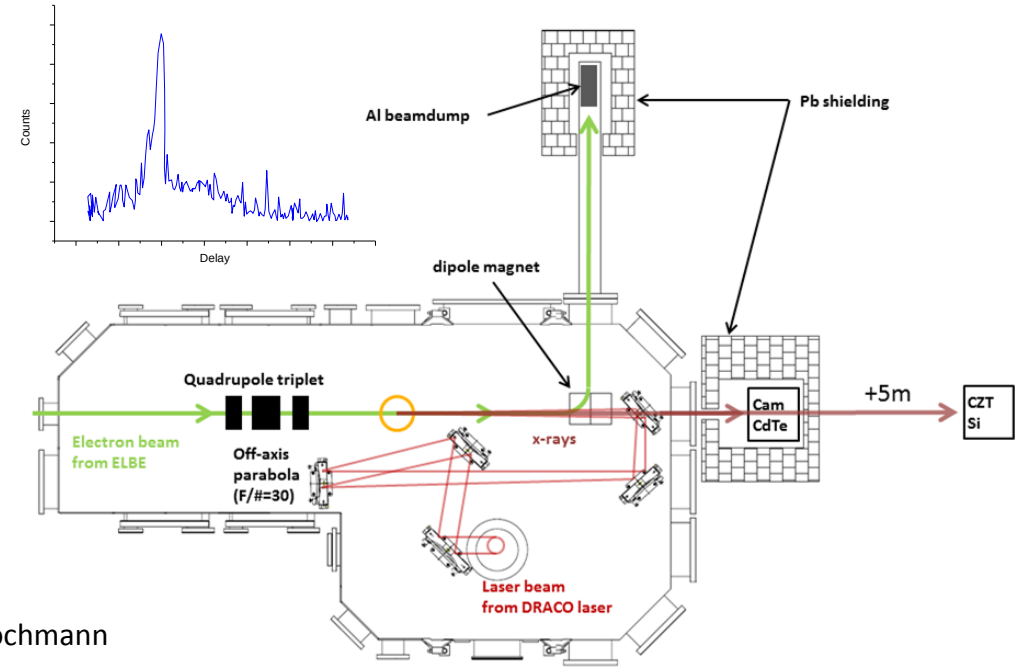


Thomson Scattering





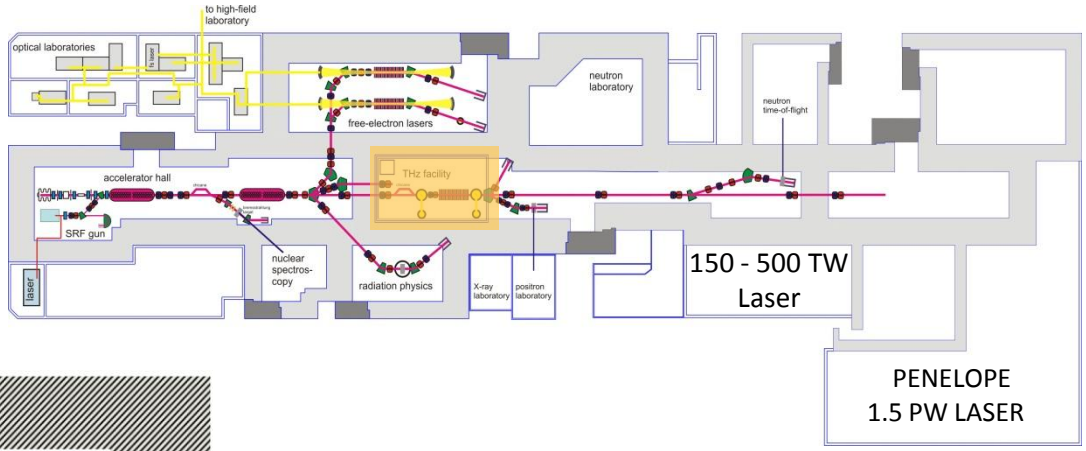
2011:
First experiments in head-on setup



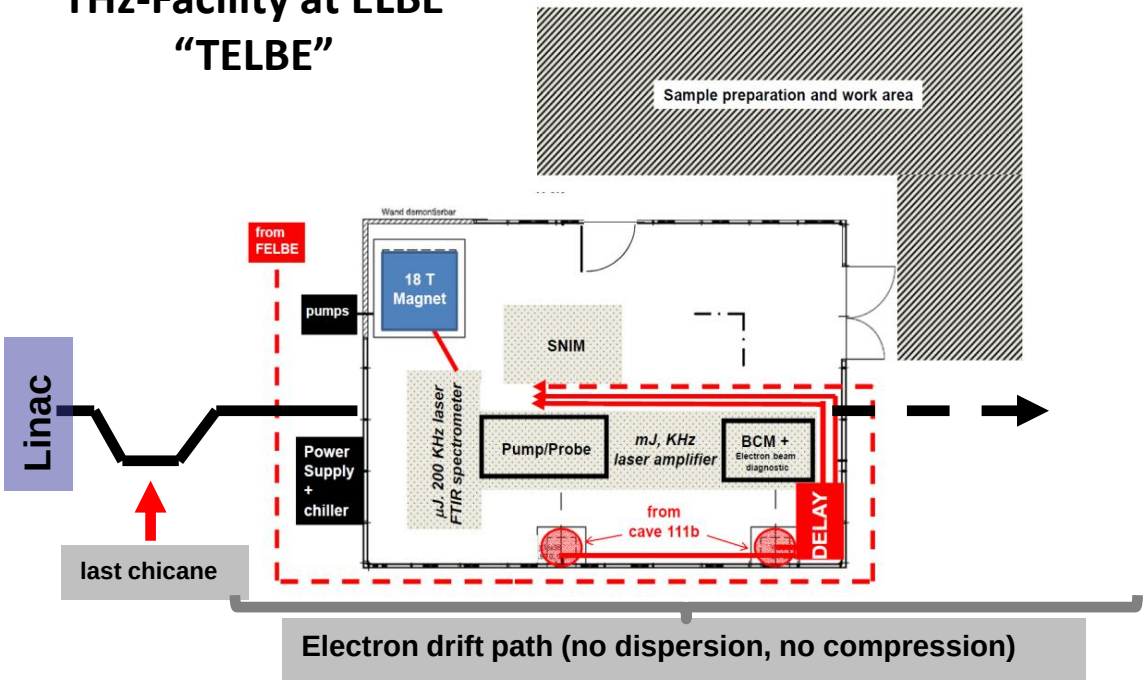
X-rays:
- tunable
- ultra-short
- narrow bandwidth
- adjustable polarization

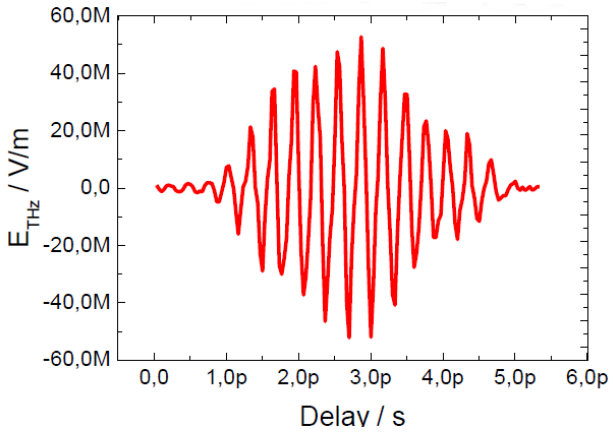
Courtesy: A. Jochmann

THz Pump Probe Experiments



THz-Facility at ELBE "TELBE"



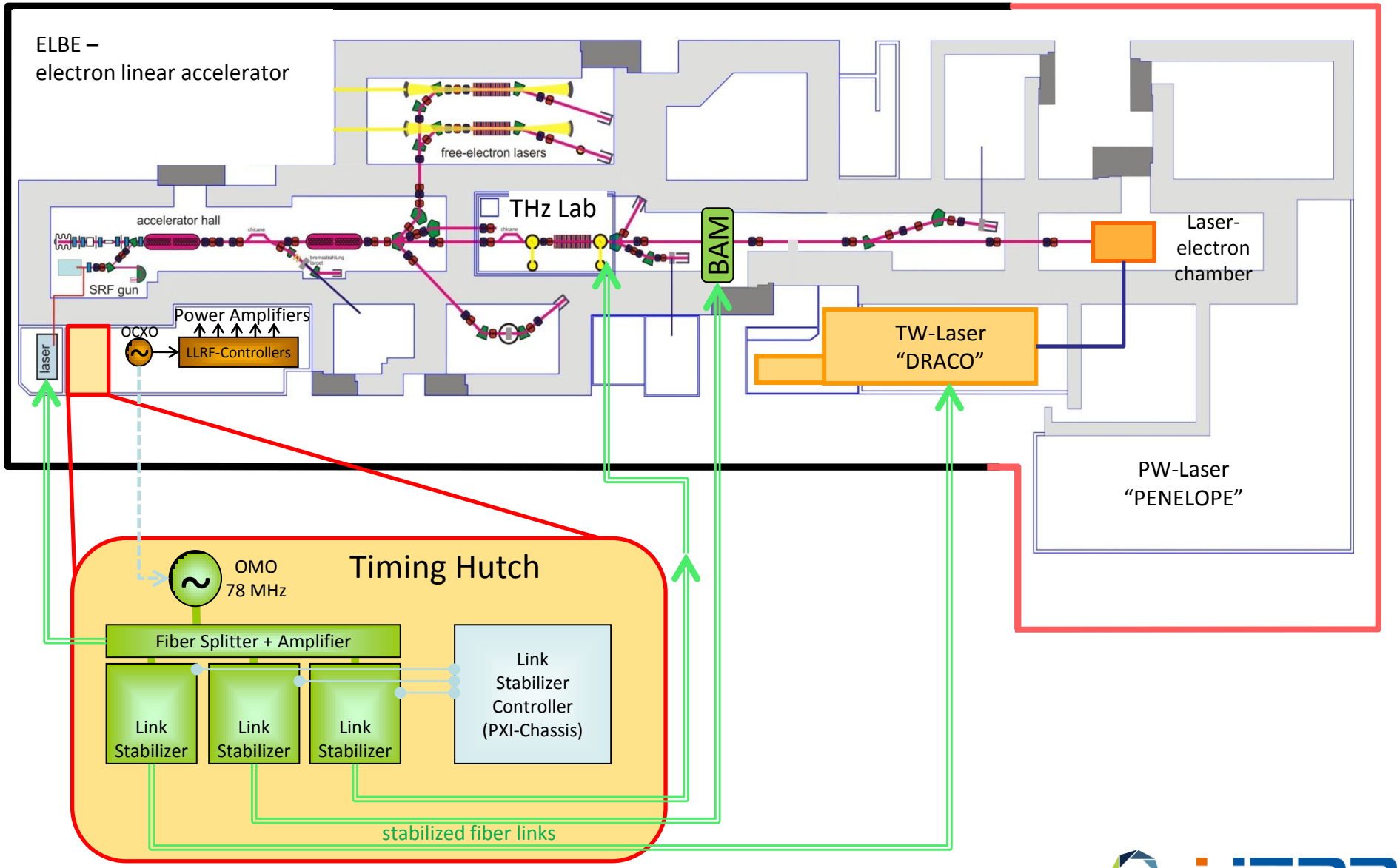


3 THz pulse of the pilot super-radiant THz facility at FLASH

M. Först, M.C. Hoffmann, A. Dienst, S. Kaiser, M. Rini, R.I. Tobey, M. Gensch, C. Manzoni, A. Cavalleri,*THz control in correlated electron solids*, in *Terahertz Spectroscopy and Imaging*, 1 Springer Series in Optical Sciences 171,

probing sub cycle E-field induced dynamics by synchronized 100 fs laser pulses

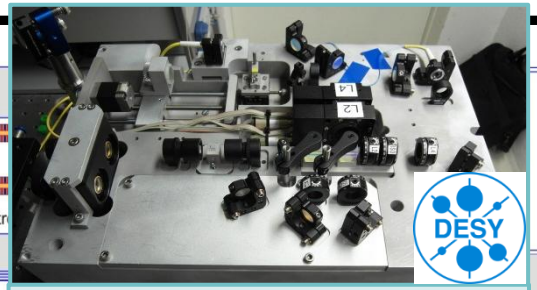
Synchronization System



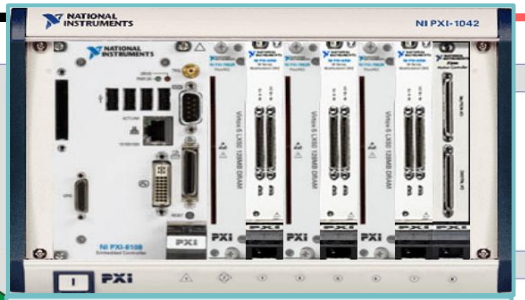
Synchronization System

Onefive Origami 15

Repetition rate	78 MHz
Wavelength	1560 nm
Bandwidth	14 nm
Pulse duration (FWHM)	180 fs
Timing jitter [1kHz;10MHz]	<6 fs



DESY Link Stabilizer
Optical cross correlator
Piezo-stretcher + delay stage
Polarization control
Dispersion compensation
RF phase detector



National Instruments PXI Chassis
Controller (slow control)
FPGA with fast I/Os (fast control)
Analogue input modules

TW-L
"DRACO"

PW-Laser
"PENELOPE"

Timing Hutch

OMO
78 MHz

Fiber Splitter + Amplifier

Link Stabilizer

Link Stabilizer

Link Stabilizer

Link Stabilizer Controller (PXI-Chassis)

stabilized fiber links